GOAL PROGRAMMING TANKER BEDDOWN DECISIONS

GRADUATE RESEARCH PROJECT

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Abstract

With the reduction of forward basing of U.S. military forces, the increase in global operations and a move toward expeditionary forces, the United States Air Force's tanker fleet is increasingly crucial to the success of all military services. Past reductions of the Air Force's tanker fleet and an ever increasing age of the tanker fleet makes fast, efficient, and effective planning a must. A critical aspect of tanker planning, that affects all other aspects of tanker operations, is the beddown decision. Beddown decisions directly affect the amount of fuel that can be offloaded to receivers and the number of tanker sorties that can be flown in support of operations. Given the importance of tanker aircraft to mission success, planners still lack rough cut planning tools that can assist in the early planning stages of tanker employment.

By combining research conducted by Major Mark Macdonald and Captain Michael Sere, a rough cut goal program can be developed that will assist tanker planners in making beddown decision. This tool can provide planners with the data required to make beddown decision based off potential capabilities and possible capability trade-offs. While this tool is not suitable to plan or conduct operations with, it will allow planners to quickly calculate potential capabilities and assist in the planning process.

Acknowledgements

I would like to thank my advisor, Dr. Alan W. Johnson, for his support and guidance during this research. His ability to enable an Army officer to understand Air Force operations allowed me to research and better understand a critical aspect of Air Force operations. I would also like to thank Major Ken Marentette, a fellow student and Air Force officer, who greatly assisted me with my lack of skill with Microsoft Excel and math.

Chris Hackler

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GOAL PROGRAMMING TANKER BEDDOWN DECISIONS

I. Introduction

"Limitation caused by tanker basing decreased off-load capability and further increased the number of tankers required. The distance of some tanker locations from refueling areas meant less fuel available for off-load ……Short runways at several locations reduced available fuel off- loads even more by decreasing tanker takeoff fuel."

Kosovo and Theater Air Mobility
Lt Gen William J. Begert, 1999

1.1 Background

Air refueling has had a direct impact on land, sea, and air operations starting with the Vietnam War (Cohen, 2001). Its continued importance to current operations can be verified in that the United States Air Force (USAF) considers air refueling to be one of its seventeen key operating functions (AFDD-1, 2003).

Air refueling was a key factor in the success of Operation Desert Shield and Desert Storm. USAF tankers flew over 34,000 sorties, performed 85,000 refueling missions, and offloaded 1.2 billion pounds of fuel (Cohen et al, 1993). The USAF operated a total of 262 KC-135s and 46 KC-10s from 21 locations in 10 countries (Cohen et al., 1993). Though the magnitude and success of the refueling mission is impressive there were numerous problems. One of the pressing problems was that the beddown of tanker aircraft was constantly adjusted throughout Desert Shield and Desert Storm (Cohen et al, 1993). The changes in beddown location resulted from host nation sensitivities, ramp congestion, and mismatches between aircraft and support equipment (Cohen et al, 1993).

During Operation Allied Force, the USAF operated 185 tankers, flew over 5000 sorties, and offloaded 250 million pounds of fuel. This effort supported over 24,000 combat and combat support missions (Begert, 1999). Though lessons learned during Desert Shield and Storm improved air refueling operations conducted during Operation Allied Force, beddown of tanker aircraft remained a problem. During the initial stages tanker aircraft were beddown at 5 bases that provided optimal operating bases for air refueling missions, but when the number of tanker aircraft grew to 175 planners were forced to find other suitable bases. Of the twenty-five airfields surveyed by United States Air Force Europe (USAFE), seven were deemed suitable for tanker operations. The new bases selected were as far away as France and Hungary. The basing of tanker aircraft at distant locations decreased the amount of fuel that could be offloaded and thus increased the number of tankers required to support operations (Begert, 1999). The short runways at several selected airfields also limited the amount of fuel that tanker aircraft could take off with which again decreases the amount that could be offloaded. Another factor affecting tanker beddown was political constraints or host nation support. Some countries denied the use of their airspace to support combat operations forcing the utilization of others routes for combat aircraft that were not fuel efficient (Begert, 1999).

At the start of Operation Iraqi Freedom the USAF deployed 159 tankers beddown at over fifteen locations. On the first night of the war Air Force, Navy, and Marine Corps tankers offloaded twelve million pounds of fuel (Burgess, 2003). The number of tanker aircraft available was not a constraint on current operations, but the basing of the tanker aircraft was. United States Central Command (USCENTCOM) planners initially planned on basing thirty-six USAF tankers in Turkey to support Navy strikes into northern Iraq. When the Turkish government refused the U.S. use of its airfields USCENTCOM planners scrambled to find suitable locations for tanker beddown. According to Rear

Admiral David C. Nichols Jr., commander of the Naval Strike and Warfare Center, the problem was not so much the number of tankers available as it was the lack of beddown capabilities (Burgess, 2003). Once again the issues of suitable airfields and host nation support limited the efficiency of tanker operations.

As the United States military continues to close foreign bases and concentrate forces on U.S. soil, the need to find optimal beddown sites for tanker aircraft during operations will increase.

1.2 Problem Motivation

The Global War on Terror has placed an incredible strain on the Air Force's limited tanker aircraft causing most tactical and strategic planners to view tanker aircraft as constraints to operations. Currently planners are utilizing powerful, time consuming analytical tools such as the Combined Mating and Ranging Planning System (CMARPS) and the Air Refueling Combat Employment Model (ARCEM) to plan both deployment and employment operations for tanker aircraft (MacDonald, 2005, 50). Given the difficulty of using the analytical tools available, several theses (MacDonald (2005), Romero (2006), Miller (2005), Annaballi (2001), and one dissertation Wiley 2001)) propose different quick look tools to decrease the time required to model tanker employment and deployment, but none model the beddown problem. Most tanker planning decision are directly affected by the beddown base of the tanker aircraft, but these quick look tools all make assumptions about the beddown bases. Major Mark MacDonald proposed in his research that "basing is a crucial component of tanker employment planning, and is one facet that readily lends itself to extended analysis and optimization" (MacDonald, 2005, 52).

1.3 Problem Statement

Interviews conducted by MacDonald with HQ AF Mobility Operations School, CENTAF Chief of Tanker Planning, and the KC-135 Tanker Weapons School clearly shows a need for a quick look tool to assist planners in making optimal beddown decisions (MacDonald, 2005, 60). Operation Desert Shield/Storm, Operation Allied Force, and Operation Iraqi Freedom have demonstrated that the basing of tanker aircraft is an ever changing event that has a direct impact on all other military operations. Without an analytical tool to assist planners the less than optimal beddown decision will negatively affect all other operations. This directly leads to the question, how can the optimal tanker theater basing structure to support a given receiver requirement be determined?

1.4 Research Objectives

The fundamental goal of this research is to provide an easy to use quick look multi-objective optimization tool that will allow planners to make timely tanker beddown decisions during employment operations.

Research conducted by MacDonald (2005) and Sere (2005) lays the ground work for developing a tool to model beddown decision. MacDonald proposes an outline to model the tanker beddown decision in his research, but stops short of developing one. Sere’s research develops an Excel based goal programming spreadsheet to model en route airfield decision for airlift aircraft. The combination of ideas and data from both researchers provides the necessary tools to develop an analytical tool to aid planners making tanker beddown decisions.

1.5 Scope

The scope of this research project will be limited to modeling beddown bases during tanker employment operations and will not address deployment operations. The focus will be on providing planners with an easy to use spreadsheet based quick look tool that will assist in making optimal decisions. In order to determine the optimal beddown decision the following research question will be answered:

> Given suitable and available airfields, airfield characteristics, location of refuel points, number of tanker aircraft available, and the maximum amount of fuel to be offloaded, what is the optimal beddown plan to support operations?

The model will look at how the constraints of 1) aircraft utilization rates, 2) fuel offload, 3) maximum number of tanker aircraft available, 4) daily fuel availably and support infrastructure at the airfield, and 5) security level of airfield affect optimal solutions for tanker beddown decisions.

1.6 Implications

This research can be utilized immediately in tanker employment planning to help planners make decisions that optimally utilize limited tanker aircraft. Further, it can be used to reduce the time required to use complicated powerful analytical tools like CMARPS by providing a good starting point which can reduce the timed needed to run the program. These efforts will hopefully facilitate the tanker employment planning process and allow for more efficient use of limited resources.

1.7 Preview

This research paper is organized as follows. Chapter II reviews the relevant literature. Chapter III summarizes the methodology used in answering the research problem. Chapter IV presents the findings and analysis of the research. Finally chapter V provides conclusions and makes recommendations for future research.

II. Literature Review

2.1 Introduction

Multiple research projects have focused on the complex task of planning air refueling operations to support both combat and support. With the majority of the prior research focused on determining the optimal or minimum number of tanker aircraft required, none have looked to provide planners with a quick look tool to support beddown decisions.

2.2 Handbook for Tanker Employment Modeling

In 2005 Major Mark MacDonald, USAF, wrote a research paper titled *Handbook for Tanker Employment Modeling*. The intent of his paper was "to serve as a foundation for tanker employment studies and research (MacDonald, 2005)." MacDonald does not actually model the tanker beddown problem, but he develops a reference for factors vital to planning tankers. MacDonald's research provides an overview of tanker employment, a synopsis of current research in tanker operations, and a collection of tanker planning factors.

Based off research and interviews conducted with HW AF Mobility Operations School, CENTAF Chief of Tanker Planning, and the KC-135 Tanker Weapons School, MacDonald proposes two topics for further research. The first is to model the beddown decisions for tanker aircraft. The second is to analyze and possibly optimize the Air Tasking Order (ATO) process for tanker aircraft. Focusing on the modeling of the tanker beddown problem, MacDonald states in his research that when selecting a group of potential beddown bases tanker planners consider four main factors: 1) Maximum on the

Ground (MOG), 2) threats and security, 3) location with respect to enemy, and 4) host nation support (MacDonald, 2005). MacDonald goes on to state that once a group of potential beddown bases are selected that planners look at the following specific selection criteria: 1) distance to refueling track, 2) airfield characteristics, 3) parking availability, and 4) base fuel capacity and delivery systems (MacDonald, 2005).

MacDonald proposes a general framework for an optimization model for tanker beddown. He proposes that by maximizing aircraft and aircrew utilization rates, minimizing the number of tankers required and maximizing the amount of fuel available to be offloaded, the optimal beddown base of tankers can be determined. His model is subject to the following.

Assumptions

- Receiver sortie requirements are identified as a sortie count per day

Given

- Expected location of refueling tracks
- Aircraft and crew turn time
- Aircraft mechanical (MX) reliability rate
- Aircrew Duty Not Including Flying (DNIF) rate
- List of acceptable airfields
- Maximum aircraft takeoff weights for given runway lengths
- Average aircraft fuel burn rate

Constraints

- Aircrew maximum daily and 30/90 day flying times
- Available KC-135 and KC-10 aircraft and aircrew
- Minimum acceptable airfield conditions:
    1) runway length

2) parking availability

3) maximum parking, taxiway, runway weights

4) fuel availability

5) security level

6) infrastructure

- Minimum and maximum number of aircraft per base

MacDonald’s proposed model sets the stage for further research and establishes a foundation to develop an analytical tool to model beddown decisions. He also proposes several simplifying assumptions and areas to add fidelity to any model developed.

2.3 Strategic Airlift En Route Analysis and Considerations to Support the Global War on Terrorism

In his 2005 AFIT thesis, Captain Michael Sere developed a goal programming-based scoring methodology imbedded in an Excel spreadsheet to assist planners in selecting en route airfields for airlift aircraft. Sere models the following factors: 1) the distance from various origins to the en route airfield of interest and the distance from the en route to various destinations, 2) the amount of parking capacity available at potential en route airfields, 3) the fuel capability present at these airfields to support strategic aircraft flow, 4) diplomatic relations with the en route host countries, 5) airfield distance from coastal seaports, and 6) the number of strategic aircraft capable airfields within a predetermined range of the potential en route (Sere, 2005).

With many planning similar factors for strategic airlift and tanker operations, it is possible to look at Captain Sere’s research with the tanker beddown problem in mind and see how his research could be utilized. Sere’s first factor of distance is crucial for tanker operations and is one of MacDonald's stated planning factors for tanker operations. Sere's second factor of parking capacity directly supports two of MacDonald's stated planning factors, MOG and parking availability. Sere's third factor, fuel capability present at the airfield directly supports MacDonald's factor of base fuel capacity and delivery systems. While not directly related to MacDonald's factor of threat and security or location with respect to the enemy, Sere's fourth factor of diplomatic relationship with the en route host country can be modified to model threat.

A summary of Sere's goal program is below.

$$\min Q$$

$$\text{where} \quad Q = \begin{cases} \sum_{i=1}^{6} \frac{w^-_i d_i^- + w^+_i d_i^+}{t_i} & l_1 + l_2 \le 8{,}500 \\ 1 & l_1 + l_2 > 8{,}500 \end{cases}$$

subject to

$$L + d_1^- - d_1^+ = T_1$$
$$m + d_2^- - d_2^+ = T_2$$
$$f + d_3^- - d_3^+ = T_3$$
$$r + d_4^- - d_4^+ = T_4$$
$$c + d_5^- - d_5^+ = T_5$$
$$a + d_6^- - d_6^+ = T_6$$

D = overall en route range from origin to destination

L = max (l_1, l_2) = limiting factor leg distance or critical leg

m = en route wide-body aircraft parking MOG

f = en route fuel capability

r = en route country diplomatic relations

c = en route proximity to coastal seaports

a = number of airfields within 1,750 nm of the en route

T_i = Target defined in the model for the *i* factor considered

Table 1. Sere's Goal Program Setup

Goal #	Goal	Symbol	Range	Target	Negative Deviation	Positive Deviation	Negative Weight	Positive Weight
1	Critical leg, $\max(l_1, l_2)$	L	$D/2 \le L \le D$	$D/2$	d_1^-	d_1^+	0	w_1^+
2	En route wide-body aircraft parking MOG	m	$0 \le m \le 20$	6	d_2^-	d_2^+	w_2^-	0
3	En route fuel capability	f	$1 \le f \le 3$	2	d_3^-	d_3^+	w_3^-	0
4	En route country diplomatic relations	r	$1 \le r \le 3$	3	d_4^-	d_4^+	w_4^-	0
5	En route proximity to coastal seaports	c	$1 \le c \le 3$	2	d_5^-	d_5^+	w_5^-	0
6	Airfields within 2,250 miles of en route	a	$0 \le a \le 1{,}500$	500	d_6^-	d_6^+	w_6^-	0

Sere models similar factors for airlift operations that MacDonald proposed for the tanker beddown problem. Sere's factors of en route wide-body aircraft parking, and en route country diplomatic relations can be directly applied to a model of tanker beddown. He also establishes a framework from that can be modified to model the remaining factors identified by MacDonald. His use of a goal program also answers MacDonald's call for a tool that will provide planners with multiple options for beddown decisions and not just one optimal base.

2.4 Existing Planning Tools

A review of existing tanker employment and deployment planning tools has exposed two major weaknesses for planners: the tools are either overly complicated or they do not provide data for making beddown decisions. The origin of tanker aircraft has a direct impact on the amount of fuel that the tanker will have available for offload. The longer the flight from the point of origin to the refuel point the more fuel the tanker aircraft will consume. CMARPS models when, where, and how much air refueling is required. It also determines fuel requirements, considering factors such as restricted airspace, threat exposure, de-confliction of routes in strike zones, and time over target (Romero, 2005). CMARPS provides a wealth of data to planners, but is overly complicated, requires extensive time to run, and does not model beddown decisions. ARCEM is another tool currently used by tanker planners that focuses on tanker fuel burn rates and capabilities, but not on beddown decisions. Models recently developed by Miller (2005), Romero (2006), Annaballi (2002), and Wiley (2001) attempt to decrease the time and resource required to model tanker operations, but all treat the beddown location of tanker aircraft as an input to the model and not an output. While the outputs from these models assist planners in tanker employment and deployment, the models do not indicate if a better solution is available by altering the beddown location of the tankers. The models also do not provide the planner with credible data reference the trade offs of different beddown decisions.

2.6 Conclusion

The importance and complexity of tanker employment has resulted in numerous research projects focusing on the problem. Even with all the research being dedicated to the problem the beddown decision of tanker aircraft is still considered an input to models. MacDonald's research proposes the tanker planning community would benefit from a model of beddown decision. On a parallel path Sere has developed an analytical tool to aid the strategic airlift community in selecting new and efficient en route locations for aircraft. Combining the model proposed by Macdonald and the model developed by Sere will answer the question of how the optimal tanker theater basing structure can be determined to support a given receiver requirement.

III. Methodology

3.1 Introduction

The chapter describes the techniques and procedures used to develop the beddown goal program. First, MacDonald's proposed model of tanker beddown and Sere's model of selecting en route locations for strategic airlift are combined to develop the beddown model. Second, the major assumptions used to develop the model are discussed. Third the construction of the beddown model incorporating MacDonald's and Sere's research and assumptions is described. Finally, the methods utilized to validate the model are discussed.

3.2 Tanker Beddown Program

The Tanker Beddown Program is designed to give tanker planners a tool to get a rough cut determination of the performance capabilities of numerous potential beddown bases early in the planning stage. This foundation for this research is Major MacDonald's graduate research project, *Handbook for Tanker Employment Modeling*. Major MacDonald proposes the desired output for determining the optimal beddown bases is:

- List of optimal beddown bases to include:
    1) Number of KC-135s and KC-10s needed at each base
    2) Number of respective crews needed at each base
- List of qualifying assumptions behind answer
    1) Maximum offload for each aircraft type at each base
    2) Maximum number of daily sorties supported at each base

3) Aircraft and aircrew UTE rate per aircraft per base

4) Average sortie duration per aircraft per base

This research will model all these outputs with the exception of the number of KC-135s and KC-10s needed at each base, the number of respective crews needed at each base, and the average sortie duration. The Tanker Beddown Program will model the number of tankers available and average sortie duration as a user input, and an assumption will be made that the required number of air crews will not be a limiting factor for the model.

With multiple goals and objectives involved in determining the optimal beddown decisions a tool that determined one optimal solution would be ineffective. Planners may have to choose between multiple locations and balance their decision based off changing goals. Linear programming would provide an optimal decision, but would not enable the constraint flexibility needed for commanders to make required trade-off decisions. Goal programming provides a means of determining multiple solutions and provides the planner with the data required to make informed decisions. Sere's research serves as the basis for developing the Tanker Beddown Basic Tool. Sere's Goal Program Basis Tool is modified to model the factors that MacDonald proposes as the desired output for a beddown model. This research incorporates variables used in MacDonald's research and the additional variables of threat, fuel availability, and KC-135 and KC-10 MOG.

3.3 Assumptions

In an effort to maintain the quick look capability of this model some factors affecting tanker beddown decisions will not be modeled. The main assumptions of this model are first; sufficient aircrews are available at each beddown location to meet requirements, second; a fixed loiter time is used when calculating average sortie duration, and third; daily tanker sortie requirements will be determined by the following formulas:

$$\text{KC-135s Only:} \quad \frac{\text{Receiver Daily Sortie Count}}{4} = \text{Tanker Daily Sortie Count}$$

$$\text{KC-135/KC-10 Mix:} \quad \frac{\text{Receiver Daily Sortie Count}}{5.6} = \text{Tanker Daily Sortie Count}$$

Figure 1. Daily Tanker Sortie Requirements Formulas (MacDonald, 2005)

3.4 Goal Programming Methodology

In order to provide planners with the fidelity they need to make complex decisions about tanker beddown a multi-objective optimization program was developed in Excel. The factors chosen for output in this tool include 1) aircraft utilization rate of sorties per day per aircraft, 2) maximum sorties per day for all aircraft, 3) average amount of fuel available to offload to receivers in a 24 hour period, 4) KC-10 availability, 5) KC-135 availability, 6) the average daily amount of fuel available at the airfield measured in pounds per day, 7) the threat at the proposed airfields.

3.5 Goal Programming Definitions

When selecting potential beddown locations for tankers, planners consider the following factors 1) MOG, 2) threats and security, 3) location with respect to the enemy, and 4) host nation support (MacDonald, 2005). This research uses seven factors to model the beddown decision. There are consistent with MacDonald's and Sere's research and are now described.

The first two factors selected are aircraft utilization (UTE) rates. For this model aircraft UTE rate (sorties per day for a single aircraft) and maximum sorties per day will be modeled. Depending on how the formulas in figure 2 are manipulated, aircraft UTE rates provide planners with the necessary data to make informed decision. The formulas can be used to determine the number of sorties a single aircraft can fly in 24 hours, the number of tanker aircraft required to support a given mission, or the maximum amount of sorties a population of tankers can support. Aircraft UTE rates are determined dividing 24 (hours/day) by the sum of the average sortie duration and the aircraft turn time. The formulas for aircraft UTE are also listed in figure 2.

$$\text{Aircraft Cycle} = \text{Average Sortie Duration (ASD)} + \text{Aircraft Turn Time}$$

$$\text{Aircraft UTE Rate} = \frac{24\ \text{(hrs/day)}}{\text{Aircraft Cycle}}$$

$$\text{Aircraft Req'd} = \left(\frac{\text{Sorties per day}}{\text{Aircraft UTE Rate}} + \text{Alerts per day}\right) * \frac{100}{\text{MX Reliability}}$$

$$\text{Max Sorties per day} = \left(\text{Aircraft Avail} * \frac{\text{MX Reliability}}{100}\right) * \text{Aircraft UTE Rate}$$

Figure 2. Aircraft Utilization Rate Formulas (AFPAM 10-1403)

The third factor selected is the amount of fuel available for offload to receivers. The amount of fuel available for offload is a direct function of distance of the refueling point from the beddown location and amount of fuel loaded at take off. The longer the flight to the refueling point and the less fuel loaded at take off the less fuel that will be available for offload. In accordance with Air Force Pamphlet 10-1403, *Air Mobility Planning Factors* the amount of fuel available for offload to receivers is determined by the formula in figure 3.

Offload Available (per tanker)
= total fuel - (dist / TAS x fuel flow) - dest resv

Dist = total distance from takeoff to landing
TAS = average airspeed of receiver leg
fuel flow = fuel burn rate in lbs/hr
total fuel = total fuel on board at takeoff
dest resv = required fuel reserves at destination

Figure 3. Offload Available (per tanker) Formulas (AFPAM 10-1403)

Total fuel, average air speed, and destination reserve will be treated as user inputs into the model. It is beyond the scope of this model to accurately determine the take-off weights of tanker aircraft, the average air speed for each situation, or the destination reserve required for each situation. Distance will be determined by averaging the distances from a potential beddown location to all refuel points.

The fourth and fifth factors are the maximum number of KC-10s and KC-135s that an airfield can support. MOG is the maximum number of aircraft that can be accommodated at an airfield on the ground at a given time (JP 4-01-05, 2002). Understanding the limiting factor of MOG is critical to ensure the airfield can support the maximum number of sorties determined when figuring aircraft UTE rates. MOG for tankers can be defined in terms of parking space, or in terms of the ability to perform aircraft servicing tasks simultaneously, or refueling (JP 4-01-05, 2002).

The sixth factor is the daily average amount of fuel available at the proposed airfields. The average amount of fuel available on a daily basis is a crucial factor when planning the beddown of tanker aircraft. Fuel availability takes into account not only the physical storage capacity of the beddown base, but also the base's delivery systems. If the selected airfield does not have sufficient logistical infrastructure to handle large quantities of fuel or sufficient quantities of fuel, the tanker fleet positioned there will be underutilized.

The threat at the proposed airfield is the final factor modeled. Threat will be treated as a user input based off the current situation. For the purpose of this research threat will be modeled on a scale of one to three in the following way;

a. Limited threat of terrorist attack at point of take-off and landing and no direct armed conflict in the area

b. Increased threat of terrorist attack at point of take-off and landing and no direct armed conflict in the area

c. Probable terrorist attack at point of take-off and landing and active armed conflict in the area

3.6 Goal Programming Setup

$$\min Q$$

$$where \quad Q = \begin{cases} \sum_{i=1}^{7} \dfrac{w^-_i d^-_i + w^+_i d^+_i}{t_i} \\ 1 \quad c < 0 \end{cases}$$

$$subject\ to$$

$$u + d^-_1 - d^+_1 = T_1$$

$$s + d^-_2 - d^+_2 = T_2$$

$$c + d^-_3 - d^+_3 = T_3$$

$$m_1 + d^-_4 - d^+_4 = T_4$$

$$m_2 + d^-_5 - d^+_5 = T_5$$

$$f + d^-_6 - d^+_6 = T_6$$

$$t + d^-_7 - d^+_7 = T_7$$

Table 2. Goal Program Setup

Goal #	Goal	Symbol	Range	TGT	Negative Deviation	Positive Deviation	Negative Weight	Positive Weight
1	Sorties per Day	u	$0 \leq u \leq 10$	4	d_1^-	d_1^+	w_1^-	w_1^+
2	Max Sorties	s	$0 \leq s \leq 45$	45	d_2^-	d_2^+	w_2^-	w_2^+
3	24 hr Offload	c	$0 \leq c \leq 2{,}500{,}000$	1,500,000	d_3^-	d_3^+	w_3^-	w_3^+
4	KC-10 MOG	m_1	$0 \leq m_1 \leq 20$	5	d_4^-	d_4^+	w_4^-	w_4^+
5	KC-135 MOG	m_2	$0 \leq m_2 \leq 20$	14	d_5^-	d_5^+	w_5^-	w_5^+
6	Fuel Available	f	$0 \leq f \leq 6{,}000{,}000$	4,000,000	d_6^-	d_6^+	w_6^-	w_6^+
7	Threat	t	$0 \leq t \leq 3$	1	d_7^-	d_7^+	w_7^-	w_7^+

3.7 Tanker Beddown Program

The Tanker Beddown Program is an Excel spreadsheet goal program. The spreadsheet consists of the following five worksheets: User Inputs, Results, Distance Calculator, UTE Calculator, and Offload Calculator. It is designed to require the user to input data into only one worksheet. All results and critical calculations are grouped on a second worksheet.

The User Inputs worksheet captures all vital information that the spreadsheet will require to calculate the Q score, determine distances to refuel points, determine tanker offload capability, and determine aircraft utilization rates (see Figure 4). The user is prompted to input the following information for each beddown base:

1) Target goal for each variable

2) Weight assigned to each variable

3) Location utilizing latitude and longitude

4) KC-10 MOG and KC-135 MOG

5) Amount of fuel available every 24 hours in pounds at each beddown base

6) Threat level

7) Average sortie time in hours

8) Aircraft turn time in hours

9) Fuel load for each type of tanker at take off in pounds

10) Destination reserve for each tanker type for each beddown base

11) Average airspeed for each tanker type

The user is also prompted to input the following data:

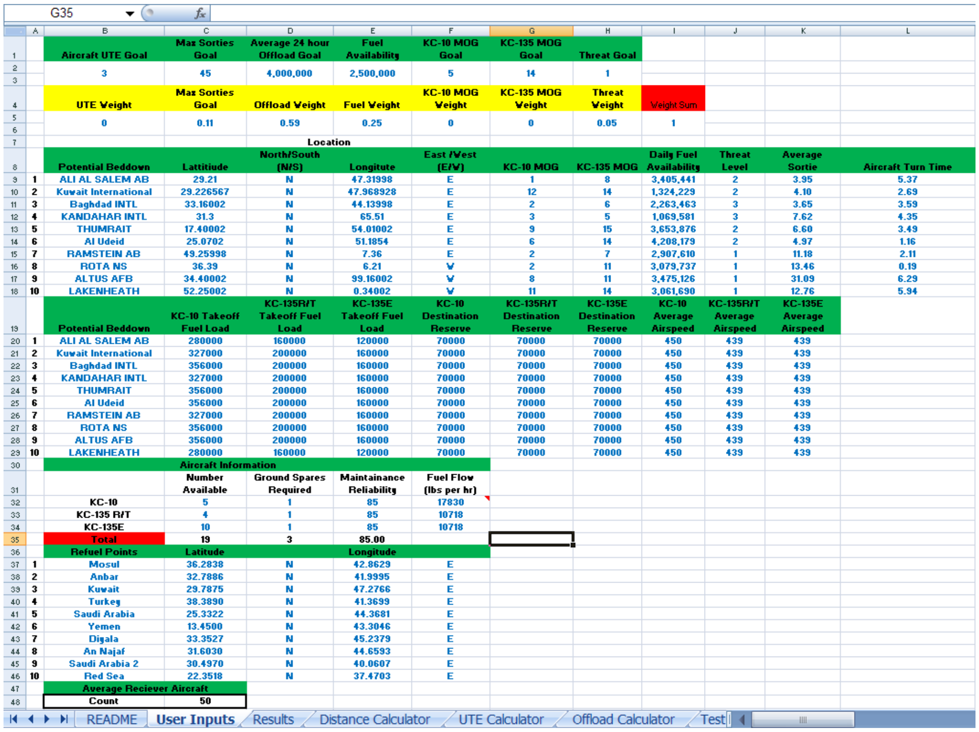
1) Number of each tanker type available for operations

2) Maintenance reliability rates for each tanker type

3) Fuel burn rate per tanker type in pounds per hour

4) Location of each refuel point utilizing latitude and longitude

5) Average number of receiver aircraft



Aircraft UTE Goal	Max Sorties Goal	Average 24 hour Offload Goal	Fuel Availability	KC-10 MOG Goal	KC-135 MOG Goal	Threat Goal	
3	45	4,000,000	2,500,000	5	14	1	
UTE Weight	**Max Sorties Goal**	**Offload Weight**	**Fuel Weight**	**KC-10 MOG Weight**	**KC-135 MOG Weight**	**Threat Weight**	**Weight Sum**
0	0.11	0.59	0.25	0	0	0.05	1

	Potential Beddown	Lattitiude	North/South (N/S)	Longitute	East /West (E/W)	KC-10 MOG	KC-135 MOG	Daily Fuel Availability	Threat Level	Average Sortie	Aircraft Turn Time
1	ALI AL SALEM AB	29.21	N	47.31998	E	1	8	3,405,441	2	3.95	5.37
2	Kuwait International	29.226567	N	47.968928	E	12	14	1,324,229	2	4.10	2.69
3	Baghdad INTL	33.16002	N	44.13998	E	2	6	2,263,463	3	3.65	3.59
4	KANDAHAR INTL	31.3	N	65.51	E	3	5	1,069,581	3	7.62	4.35
5	THUMRAIT	17.40002	N	54.01002	E	9	15	3,653,876	2	6.60	3.49
6	Al Udeid	25.0702	N	51.1854	E	6	14	4,208,179	2	4.97	1.16
7	RAMSTEIN AB	49.25998	N	7.36	E	2	7	2,907,610	1	11.18	2.11
8	ROTA NS	36.39	N	6.21	W	2	11	3,079,737	1	13.46	0.19
9	ALTUS AFB	34.40002	N	99.16002	W	8	11	3,475,126	1	31.09	6.29
10	LAKENHEATH	52.25002	N	0.34002	W	11	14	3,061,690	1	12.76	5.94

	Potential Beddown	KC-10 Takeoff Fuel Load	KC-135R/T Takeoff Fuel Load	KC-135E Takeoff Fuel Load	KC-10 Destination Reserve	KC-135R/T Destination Reserve	KC-135E Destination Reserve	KC-10 Average Airspeed	KC-135R/T Average Airspeed	KC-135E Average Airspeed
1	ALI AL SALEM AB	280000	160000	120000	70000	70000	70000	450	439	439
2	Kuwait International	327000	200000	160000	70000	70000	70000	450	439	439
3	Baghdad INTL	356000	200000	160000	70000	70000	70000	450	439	439
4	KANDAHAR INTL	327000	200000	160000	70000	70000	70000	450	439	439
5	THUMRAIT	356000	200000	160000	70000	70000	70000	450	439	439
6	Al Udeid	356000	200000	160000	70000	70000	70000	450	439	439
7	RAMSTEIN AB	327000	200000	160000	70000	70000	70000	450	439	439
8	ROTA NS	356000	200000	160000	70000	70000	70000	450	439	439
9	ALTUS AFB	356000	200000	160000	70000	70000	70000	450	439	439
10	LAKENHEATH	280000	160000	120000	70000	70000	70000	450	439	439

Aircraft Information				
	Number Available	Ground Spares Required	Maintainance Reliability	Fuel Flow (lbs per hr)
KC-10	5	1	85	17830
KC-135 R/T	4	1	85	10718
KC-135E	10	1	85	10718
Total	19	3	85.00	

	Refuel Points	Latitude		Longitude	
1	Mosul	36.2838	N	42.8629	E
2	Anbar	32.7886	N	41.9995	E
3	Kuwait	29.7875	N	47.2766	E
4	Turkey	38.3890	N	41.3699	E
5	Saudi Arabia	25.3322	N	44.3681	E
6	Yemen	13.4500	N	43.3046	E
7	Diyala	33.3527	N	45.2379	E
8	An Najaf	31.6030	N	44.6593	E
9	Saudi Arabia 2	30.4970	N	40.0607	E
10	Red Sea	22.3518	N	37.4703	E

Average Reciever Aircraft	
Count	50

Figure 4. User Input Worksheet

The Results worksheet captures the important calculations from other worksheets and calculates the Q score for each beddown base (see Figure 5). Q scores are color coded from lowest value to highest value. The lowest values are highlighted green and the highest values are highlighted red. Any beddown base that has an average 24 hour offload less than or equal to zero will assigned a Q score of 1. This will ensure unfeasible options are not rewarded for other favorable characteristics. In order to prevent a beddown base from having a larger average 24 hour offload than the amount of fuel available at the beddown base, the minimum value between 24 hour offload and fuel available minus fuel expended during operations will be selected as the value for 24 hour offload (see Equation 1). Average 24 hour offload is determined utilizing equation 5.

$$\text{Average 24 hour Offload} = \min(\text{average 24 hour offload, fuel availability} - (\left(\frac{Dist}{TAS}\right) * \text{KC-10 fuel flow} + \text{KC-10 Dest Resv}) * \text{KC-10 tank gen} + \left(\frac{Dist}{TAS}\right) * \text{KC-135R/T fuel flow} + \text{KC-135R/T Dest Resv}) * \text{KC-135R/T tank gen} + \left(\frac{Dist}{TAS}\right) * \text{KC-135E fuel flow} + \text{KC-135E Dest Resv}) * \text{KC-135E tank gen})) \quad (1)$$

It is also possible for an airfield to have a higher MOG than the size of the tanker population in question. In order to prevent an airfield from receiving a lower Q score for having a higher MOG than the size of the tanker population, the minimum value between MOG and number of tankers available will be used for Q score calculations, as shown in equations 2 and 3.

$$\text{KC-10 Availability} = \min(\text{KC-10 MOG, KC-10 Available}) \quad (2)$$

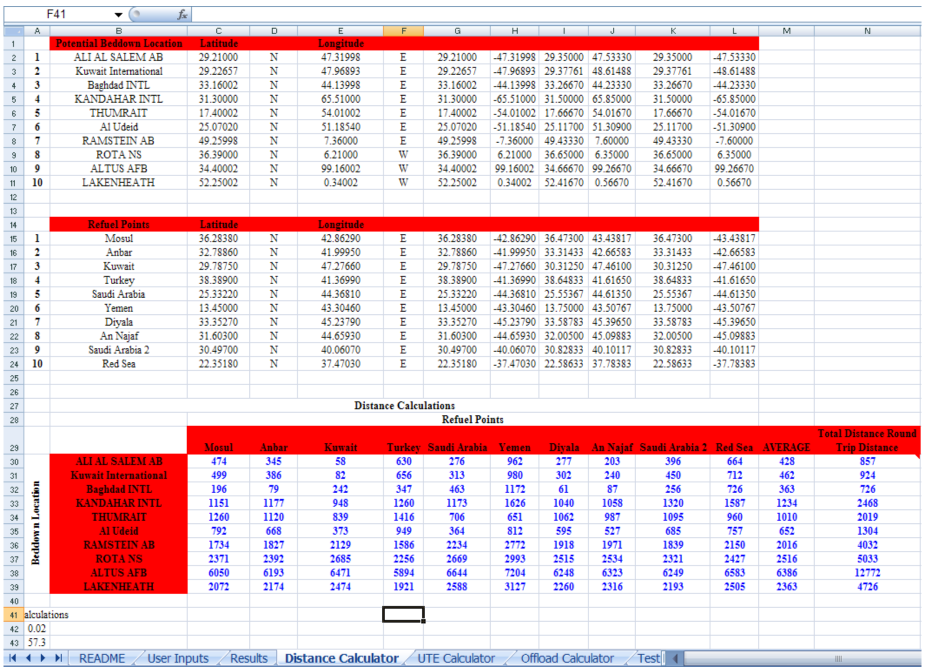
$$\text{KC-135 Availability} = \min(\text{KC-135 MOG, KC-135 Available}) \quad (3)$$

	A	B	C	D	E	F	G	H	I	J
1		Aircraft UTE Goal	Max Sorties Goal	Average 24 hour Offload Goal	Fuel Availability Goal	KC-10 MOG Goal	KC-135 MOG Goal	Threat Goal		
2–3		3	45	1,500,000	4000000	5	14	1		
4		UTE Weight	Max Sorties Goal	Offload Weight	Fuel Weight	KC-10 MOG Weight	KC-135 MOG Weight	Threat Weight		
5		w1-	w2-	w3-	w6-	w4-	w5-	w7+		
6		0.14	0.14	0.15	0.15	0.14	0.14	0.14		
7										
8		Potential Beddown	Q Score	Aircraft UTE Rate (sorties per day)	Max Sorties (per Day)	Average 24 hour Offload	Fuel Availability	KC-10 Available	KC-135 Available	Threat
9	1	ALI AL SALEM	1.0000	2.00	0.00	0	4,000,000	0	0	2
10	2	ALI AL SALEM	0.5095	2.00	6.80	1,594,809	4,000,000	2	2	2
11	3	ALI AL SALEM	0.5095	2.00	6.80	1,594,809	4,000,000	2	2	2
12	4	ALI AL SALEM	0.4609	2.00	10.20	2,270,213	4,000,000	3	3	2
13	5	ALI AL SALEM	0.4124	2.00	13.60	1,693,618	4,000,000	4	4	2
14	6	ALI AL SALEM	0.3820	2.00	20.40	1,112,017	4,000,000	5	6	2
15	7	ALI AL SALEM	0.7062	2.00	1.70	351,310	4,000,000	0	1	2
16	8	ALI AL SALEM	0.6788	2.00	1.70	446,094	4,000,000	1	0	2
17	9	ALI AL SALEM	0.5095	2.00	6.80	1,594,809	4,000,000	2	2	2
18	10	ALI AL SALEM	0.3873	2.00	18.70	1,112,017	4,000,000	5	6	2

Figure 5. Results Worksheet

The Distance Calculator determines the distance from each beddown base to each refuel point utilizing calculations developed in Captain Sere's Global En Route

Spreadsheet Tool (GERST) (see Figure 6). The distances from each separate beddown base to all refuel points are then averaged to determine the average distance from each beddown base to all refuel points. The average distance is then doubled to determine the average round trip distance from each beddown base to all refuel points. The average round trip distance will be the distance that is inputted into the calculations for fuel offload.



	Potential Beddown Location	Latitude		Longitude							
1	ALI AL SALEM AB	29.21000	N	47.31998	E	29.21000	-47.31998	29.35000	47.53330	29.35000	-47.53330
2	Kuwait International	29.22657	N	47.96893	E	29.22657	-47.96893	29.37761	48.61488	29.37761	-48.61488
3	Baghdad INTL	33.16002	N	44.13998	E	33.16002	-44.13998	33.26670	44.23330	33.26670	-44.23330
4	KANDAHAR INTL	31.30000	N	65.51000	E	31.30000	-65.51000	31.50000	65.85000	31.50000	-65.85000
5	THUMRAIT	17.40002	N	54.01002	E	17.40002	-54.01002	17.66670	54.01670	17.66670	-54.01670
6	Al Udeid	25.07020	N	51.18540	E	25.07020	-51.18540	25.11700	51.30900	25.11700	-51.30900
7	RAMSTEIN AB	49.25998	N	7.36000	E	49.25998	-7.36000	49.43330	7.60000	49.43330	-7.60000
8	ROTA NS	36.39000	N	6.21000	W	36.39000	6.21000	36.65000	6.35000	36.65000	6.35000
9	ALTUS AFB	34.40002	N	99.16002	W	34.40002	99.16002	34.66670	99.26670	34.66670	99.26670
10	LAKENHEATH	52.25002	N	0.34002	W	52.25002	0.34002	52.41670	0.56670	52.41670	0.56670

	Refuel Points	Latitude		Longitude							
1	Mosul	36.28380	N	42.86290	E	36.28380	-42.86290	36.47300	43.43817	36.47300	-43.43817
2	Anbar	32.78860	N	41.99950	E	32.78860	-41.99950	33.31433	42.66583	33.31433	-42.66583
3	Kuwait	29.78750	N	47.27660	E	29.78750	-47.27660	30.31250	47.46100	30.31250	-47.46100
4	Turkey	38.38900	N	41.36990	E	38.38900	-41.36990	38.64833	41.61650	38.64833	-41.61650
5	Saudi Arabia	25.33220	N	44.36810	E	25.33220	-44.36810	25.55367	44.61350	25.55367	-44.61350
6	Yemen	13.45000	N	43.30460	E	13.45000	-43.30460	13.75000	43.50767	13.75000	-43.50767
7	Diyala	33.35270	N	45.23790	E	33.35270	-45.23790	33.58783	45.39650	33.58783	-45.39650
8	An Najaf	31.60300	N	44.65930	E	31.60300	-44.65930	32.00500	45.09883	32.00500	-45.09883
9	Saudi Arabia 2	30.49700	N	40.06070	E	30.49700	-40.06070	30.82833	40.10117	30.82833	-40.10117
10	Red Sea	22.35180	N	37.47030	E	22.35180	-37.47030	22.58633	37.78383	22.58633	-37.78383

Distance Calculations

Refuel Points

Beddown Location	Mosul	Anbar	Kuwait	Turkey	Saudi Arabia	Yemen	Diyala	An Najaf	Saudi Arabia 2	Red Sea	AVERAGE	Total Distance Round Trip Distance
ALI AL SALEM AB	474	345	58	630	276	962	277	203	396	664	428	857
Kuwait International	499	386	82	656	313	980	302	240	450	712	462	924
Baghdad INTL	196	79	242	347	463	1172	61	87	256	726	363	726
KANDAHAR INTL	1151	1177	948	1260	1173	1626	1040	1058	1320	1587	1234	2468
THUMRAIT	1260	1120	839	1416	706	651	1062	987	1095	960	1010	2019
Al Udeid	792	668	373	949	364	812	595	527	685	757	652	1304
RAMSTEIN AB	1734	1827	2129	1586	2234	2772	1918	1971	1839	2150	2016	4032
ROTA NS	2371	2392	2685	2256	2669	2993	2515	2534	2321	2427	2516	5033
ALTUS AFB	6050	6193	6471	5894	6644	7204	6248	6323	6249	6583	6386	12772
LAKENHEATH	2072	2174	2474	1921	2588	3127	2260	2316	2193	2505	2363	4726

alculations
0.02
57.3

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Figure 6. Distance Worksheet

The UTE Calculator in Figure 7 determines aircraft utilization rates for the tanker fleet in question. Aircraft cycle, aircraft UTE rate (sorties per day per aircraft), tanker sorties required, aircraft required, max sorties per day for the tanker fleet, and the maximum number of tankers available are calculated utilizing formulas from AFPAM 10-1403. Aircraft UTE rates are utilized by the Offload Calculator worksheet to determine the tanker generation per tanker type (number of sorties per tanker type by population). Aircraft UTE rates and max sorties are factors in determining the Q score for each beddown base, and the remaining factors are for user utilization.

	A	B	C	D	E	F	G	H
1								
2								
3			Aircraft Cycle	Aircraft UTE Rate (sorties per day)	Tanker Sorties Required	Aircraft Required	Max Sorties per Day	Maximum Aircraft Available
4	1	ALI AL SALEM AB	9.32	2.58	8.93	7.61	41.59	9.00
5	2	Kuwait International	6.79	3.53	8.93	6.50	57.08	19.00
6	3	Baghdad INTL	7.24	3.31	8.93	6.70	53.54	8.00
7	4	KANDAHAR INTL	11.97	2.01	8.93	8.77	32.38	8.00
8	5	THUMRAIT	10.09	2.38	8.93	7.95	38.41	19.00
9	6	Al Udeid	6.13	3.92	8.93	6.21	63.23	19.00
10	7	RAMSTEIN AB	13.29	1.81	8.93	9.35	29.16	9.00
11	8	ROTA NS	13.65	1.76	8.93	9.50	28.40	13.00
12	9	ALTUS AFB	37.38	0.64	8.93	19.89	10.37	19.00
13	10	LAKENHEATH	18.70	1.28	8.93	11.71	20.73	19.00

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Figure 7. UTE Calculator

The last worksheet is the Offload Calculator, in Figure 8. The Offload Calculator calculates the tanker generation per tanker type, the average offload per aircraft type per aircraft, and the 24 hour average offload per tanker type and the total tanker population. Tanker generation is determined by

$$\text{Tanker generation} = \frac{\min(\text{Aircraft MOG, Number of Aircraft Available})*24}{\text{Aircraft Cycle}} \tag{4}$$

The average 24 hour offload by tanker type is determined by

$$\text{Average 24 hour Offload} = \text{Average Offload per Sortie} * \text{Tanker Generation} \tag{5}$$

	Potential Beddown	KC-10 Average Offload per Sortie	KC-135R Average Offload per sortie	KC-135E Average Offload per Sortie	Average Offload per Sortie
1	ALI AL SALEM AB	176,047	69,079	29,079	91,402
2	Kuwait International	220,399	107,447	67,447	131,764
3	Baghdad INTL	257,239	112,278	72,278	147,265
4	KANDAHAR INTL	159,215	69,746	29,746	86,236
5	THUMRAIT	205,996	80,703	40,703	109,134
6	Al Udeid	234,322	98,157	58,157	130,212
7	RAMSTEIN AB	97,252	31,566	-8,434	40,128
8	ROTA NS	86,584	7,123	-32,877	20,277
9	ALTUS AFB	-220,055	-181,823	-221,823	-207,901
10	LAKENHEATH	22,741	-25,386	-65,386	-22,677

	Potential Beddown	KC-10 Average 24 hour Offload	KC-135R Average 24 hour Offload	KC-135 Average 24 hour Offload	Average 24 hour Offload
1	ALI AL SALEM AB	453,340	711,541	599,048	1,763,929
2	Kuwait International	3,895,124	1,519,134	2,383,992	7,798,251
3	Baghdad INTL	1,705,454	1,488,770	1,437,576	4,631,800
4	KANDAHAR INTL	957,684	559,370	298,210	1,815,263
5	THUMRAIT	2,449,903	767,836	968,154	4,185,893
6	Al Udeid	4,587,059	1,537,206	2,276,947	8,401,212
7	RAMSTEIN AB	351,249	228,016	-106,615	472,650
8	ROTA NS	304,471	50,096	-578,057	-223,490
9	ALTUS AFB	-706,438	-466,962	-1,424,226	-2,597,626
10	LAKENHEATH	145,931	-130,324	-839,180	-823,573

	Potential Beddown	KC-10 Tanker Generation	KC-135R Tanker Generation	KC-135E Tanker Generation
1	ALI AL SALEM AB	3	10	21
2	Kuwait International	18	14	35
3	Baghdad INTL	7	13	20
4	KANDAHAR INTL	6	8	10
5	THUMRAIT	12	10	24
6	Al Udeid	20	16	39
7	RAMSTEIN AB	4	7	13
8	ROTA NS	4	7	18
9	ALTUS AFB	3	3	6
10	LAKENHEATH	6	5	13

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Figure 8. Offload Calculator

3.8 Scenario Setup and Testing

To test the model and be able to compare the Q scores of potential beddown locations, a hypothetical scenario was developed focusing around Southwest Asia. Ten potential beddown locations and ten refuel points were selected focusing operations in and around the country of Iraq. The beddown locations were selected so that five of the beddown locations had an average distance to all refuel points of less than 1000 nautical miles, four beddown locations had an average distance to all refuel points between 1000 nautical miles and 3000 nautical miles, and one beddown location had an average distance to all refuel points greater than 6000 nautical miles. Refuel points were chosen to ensure an even distribution of points in the area of operations. The beddown locations that were selected are as follows:

1) Ali Al Salem Air Base, Kuwait
2) Kuwait International Airport, Kuwait
3) Baghdad International Airport, Iraq
4) Thumrait Airport, Oman
5) Al Udeid Air Base, Qatar
6) Ramstein Air Base, Germany
7) Rota Naval Station, Spain
8) Diego Garcia Naval Support Facility, British Indian Ocean Territory
9) Kandahar International Airport, Afghanistan
10) Altus Air Force Base, Oklahoma, USA

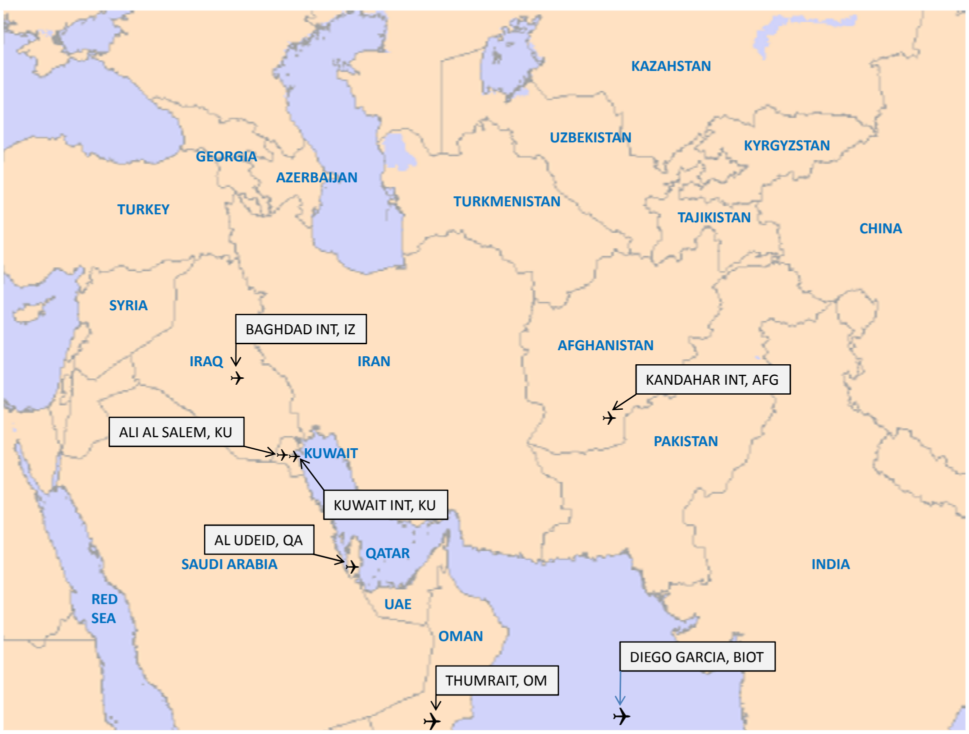

Figure 9. Map of potential beddown bases

The refuel points are as follows:

11) Mosul, Iraq

12) Al Anbar Provence, Iraq

13) Kuwait

14) Turkey

15) Saudi Arabia

16) Yemen

17) Diyala Provence, Iraq

18) An Najaf, Iraq

19) Saudi Arabia 2

20) Red Sea

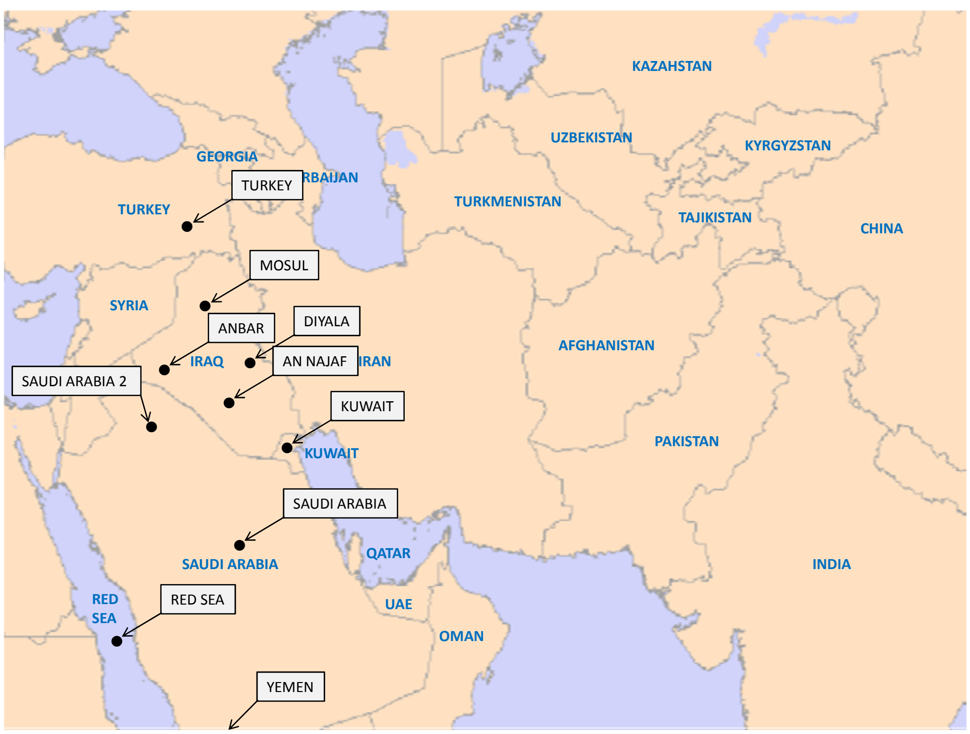

Figure 10. Map of refuel tracks

3.9 Assignment of Weights and Values

MacDonald states in his research that when selecting a group of potential beddown bases tanker planners consider four main factors: 1) MOG, 2) threats and security, 3) location with respect to enemy, and 4) host nation support (MacDonald, 2005). MacDonald goes on to state that once a group of potential beddown bases are selected that planners look at the following specific selection criteria, 1) distance to refueling track, 2) airfield characteristics, 3) parking availability, and 4) base fuel capacity and delivery systems (MacDonald, 2005).

MacDonald's criteria are captured in the Tanker Beddown Model in the following variables 1) average 24 hour offload, 2) fuel availability, 3) KC-10 and KC-135 MOG, and 4) threat. MacDonald's factors of distance to refuel track and airfield characteristics are modeled utilizing the factor of average 24 hour offload. Distance to the refuel track directly affects the amount of fuel available for offload. Airfield characteristics such as runway length and runway pavement are critical in determining the amount of fuel that an aircraft can takeoff with. For this model the tanker take off fuel load is a user input, but the airfield characteristics directly influence the calculations used to determine this amount. The criteria of host nation support and fuel capacity and delivery systems are captured in the factor of fuel availability. MacDonald's criterion of MOG is captured in the factor KC-10 MOG and KC-135 MOG. The final criteria of threat and security and location with respect to the enemy are captured by the factor threat.

Using the Iraq-focused Middle East scenario, the following weights were used in the two final model tests.

1) Average 24 hour offload: 0.40

2) Fuel availability: 0.25

3) KC-10 MOG 0.15

4) KC-135 MOG 0.10

5) Threat 0.10

Values for user inputs were selected by either using open source data, a random number generator, or data from Air Force Doctrine. A random number generator was used to determine values for the following variables 1) KC-10 MOG, 2) KC-135 MOG, 3) daily fuel available, and 4) aircraft turn time. Runway length at each beddown base was used to estimate takeoff fuel loads for the different tankers. Beddown bases with runways in excess of 12,000 feet were allocated takeoff fuel weights that equal the maximum capacity of the tanker. Beddown bases with runway lengths between 10,000 feet and 12,000 feet were allocated takeoff fuel weights in accordance with AFPAM 10-1403. Beddown bases with runways shorter than 10,000 feet were allocated a takeoff fuel weight 40,000 pounds less than the takeoff fuel weight allocated to beddown bases with runways between 10,000 feet and 12,000 feet. Destination reserve was held constant at 70,000 pounds for all aircraft types at all beddown bases, block speeds were used for average airspeeds, and burn rates were in accordance with AFPAM 10-1403 and MacDonald's research. The number of aircraft available, ground spares, and maintenance reliability were randomly selected. Average sortie duration was determined by dividing the average distance to all refuel tracks by the KC-135 block speed (439 nautical miles per hour).

IV. Results and Analysis

4.1 Introduction

Five tests were constructed to access the model. The first three tests focused on verifying equations and spreadsheet operations for the distance and offload calculators, and the effects of MOG on different calculations. The last two tests focused on verifying and stressing the model.

4.2 Test I

The purpose of Test I was to verify the interaction of the variables of average total round trip distance, average 24 hour offload, and Q scores. Test I was set up by inputting ten different beddown base locations and refuel locations, setting all weights equal, and setting all user inputs equal for all beddown bases (see Appendix A). Based off calculations used to determine the average 24 hour offload and holding all other variables equal between beddown bases, the beddown base with the shortest average total round trip distance should have smallest Q score and the largest average 24 hour offload.

Test I's results are displayed in Table 3. With the variables being set equal to each other all outputs from the model are equal with the exception of average 24 hour offload. With varying average distances, each beddown base should show varying average 24 hour offload amounts and thus varying Q scores, but upon inspection of the Q Scores it is determined that the lowest Q score is shared by four beddown bases with varying offload amounts. The four beddown bases are as follows.

1) Ali Al Salem AB

2) Kuwait International

3) Baghdad International

4) Al Udeid AB

Table 3. Goal Programming Results for Test I

Aircraft UTE Goal	Max Sorties Goal	Average 24 hour Offload Goal	Fuel Availability Goal	KC-10 MOG Goal	KC-135 MOG Goal	Threat Goal
3	25	3000000	9000000	5	5	1

UTE Weight	Max Sorties Goal	Offload Weight	Fuel Weight	KC-10 MOG Weight	KC-135 MOG Weight	Threat Weight
w1-	w2-	w3-	w6-	w4-	w5-	w7+
0.14	0.14	0.15	0.15	0.14	0.14	0.14

	Potential Beddown	Q Score	Aircraft UTE Rate (sorties per day)	Max Sorties (per Day)	Average 24 hour Offload	Fuel Availability	KC-10 Available	KC-135 Available	Threat
1	ALI AL SALEM AB	0.2315	2.00	17.00	3,768,864	9,000,000	5	5	2
2	Kuwait International	0.2315	2.00	17.00	3,711,063	9,000,000	5	5	2
3	Baghdad INTL	0.2315	2.00	17.00	3,882,201	9,000,000	5	5	2
4	KANDAHAR INTL	0.2627	2.00	17.00	2,375,514	9,000,000	5	5	2
5	THUMRAIT	0.2433	2.00	17.00	2,763,645	9,000,000	5	5	2
6	Al Udeid	0.2315	2.00	17.00	3,381,961	9,000,000	5	5	2
7	RAMSTEIN AB	0.3303	2.00	17.00	1,022,970	9,000,000	5	5	2
8	ROTA NS	0.3736	2.00	17.00	157,078	9,000,000	5	5	2
9	ALTUS AFB	1.0000	2.00	17.00	-6,536,351	9,000,000	5	5	2
10	LAKENHEATH	0.3603	2.00	17.00	422,444	9,000,000	5	5	2

Table 4 shows that the four beddown bases in question are the four beddown bases with the four shortest average distances to travel to the ten refuel tracks. The equal Q scores can be validated by the fact that all four of the beddown bases exceed the average 24 hour offload target amount of 3,000,000 pounds of fuel. Of the six remaining beddown bases that do not exceed the average 24 hour offload goal, Thumrait AB, Oman has the shortest distance and the lowest Q score.

Table 4. Goal Programming Results for Test I

Beddown Bases	Q Score	Total Distance Round Trip Distance
ALI AL SALEM AB	0.2315	857
Kuwait International	0.2315	924
Baghdad INTL	0.2315	726
KANDAHAR INTL	0.2627	2468
THUMRAIT	0.2433	2019
Al Udeid	0.2315	1304
RAMSTEIN AB	0.3303	4032
ROTA NS	0.3736	5033
ALTUS AFB	1.0000	12772
LAKENHEATH	0.3603	4726

Figures 11 and 12 show the relationship between average total distance and average 24 hour offload and the Q score. As the average total round trip distance increases the average 24 hour offload decreases. This has no effect on the Q score for beddown bases that exceed the offload goal, but for bases that do not exceed the goal Q score increases as distance increases and offload decreases. All other outputs for the model are equal across the ten beddown bases.

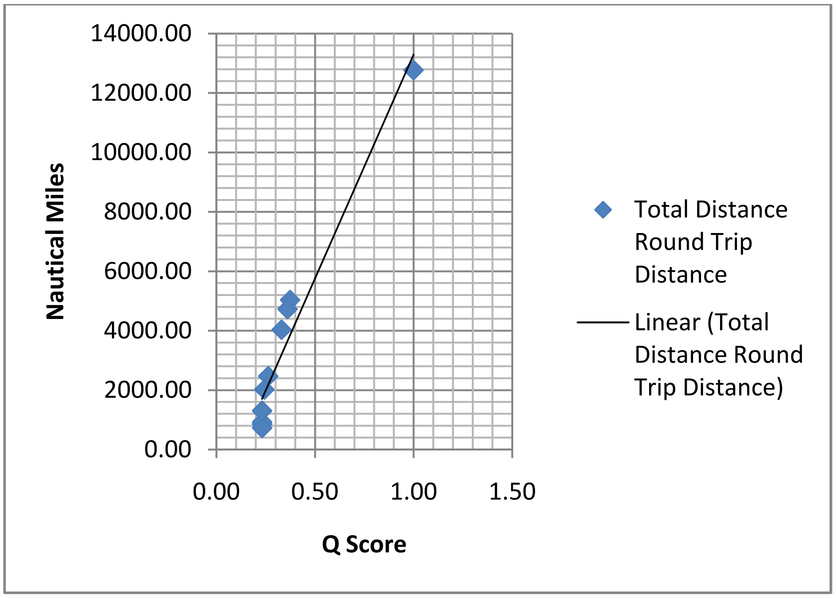

Figure 11. Test I Q Scores for Beddown Bases Compared to Average Total Distance

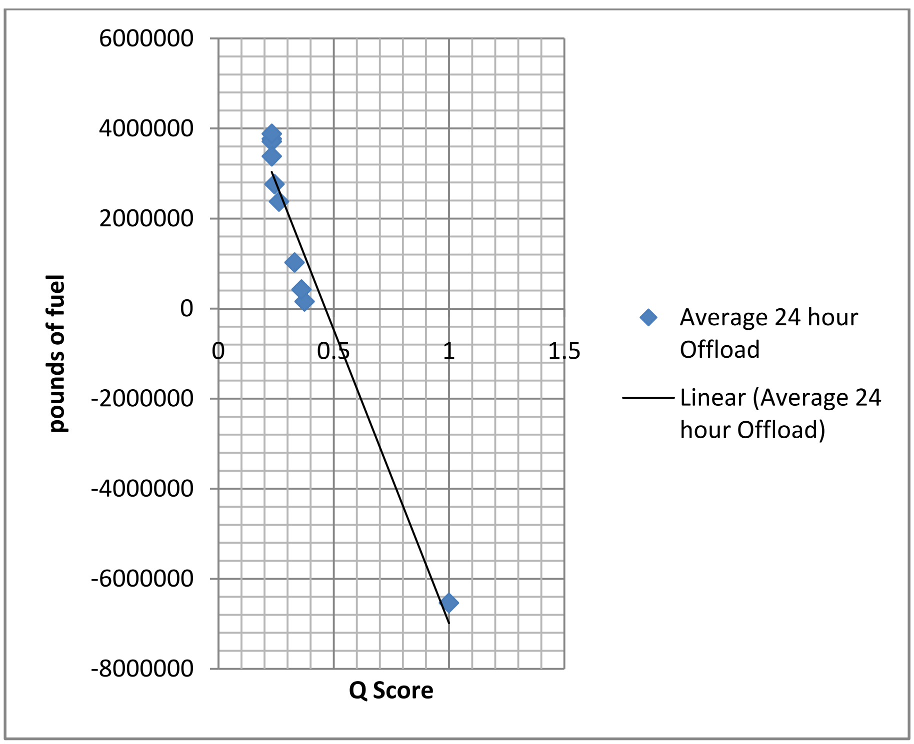

Figure 12. Test I Q Scores for Beddown Bases Compared to Offload

4.3 Test II

The purpose of Test II was to verify that equations used in the Tanker Beddown Model are consistent between the different beddown bases. For this Test I beddown base location was used in place of ten different ones. All variables, including weights, were set equal to each other respectively (see Appendix B). Table 5 shows that all outputs for the model are equal.

Table 5. Goal Programming Results for Test II

	A	B	C	D	E	F	G	H	I	J
1		Aircraft UTE Goal	Max Sorties Goal	Average 24 hour Offload Goal	Fuel Availability Goal	KC-10 MOG Goal	KC-135 MOG Goal	Threat Goal		
2		3	25	3000000	9000000	5	5	1		
3										
4		UTE Weight	Max Sorties Goal	Offload Weight	Fuel Weight	KC-10 MOG Weight	KC-135 MOG Weight	Threat Weight		
5		w1-	w2-	w3-	w6-	w4-	w5-	w7+		
6		0.14	0.14	0.15	0.15	0.14	0.14	0.14		
7										
8		Potential Beddown	Q Score	Aircraft UTE Rate (sorties per day)	Max Sorties (per Day)	Average 24 hour Offload	Fuel Availability	KC-10 Available	KC-135 Available	Threat
9	1	ALI AL SALEM AB	0.2315	2.00	17.00	3,768,864	9,000,000	5	5	2
10	2	ALI AL SALEM AB	0.2315	2.00	17.00	3,768,864	9,000,000	5	5	2
11	3	ALI AL SALEM AB	0.2315	2.00	17.00	3,768,864	9,000,000	5	5	2
12	4	ALI AL SALEM AB	0.2315	2.00	17.00	3,768,864	9,000,000	5	5	2
13	5	ALI AL SALEM AB	0.2315	2.00	17.00	3,768,864	9,000,000	5	5	2
14	6	ALI AL SALEM AB	0.2315	2.00	17.00	3,768,864	9,000,000	5	5	2
15	7	ALI AL SALEM AB	0.2315	2.00	17.00	3,768,864	9,000,000	5	5	2
16	8	ALI AL SALEM AB	0.2315	2.00	17.00	3,768,864	9,000,000	5	5	2
17	9	ALI AL SALEM AB	0.2315	2.00	17.00	3,768,864	9,000,000	5	5	2
18	10	ALI AL SALEM AB	0.2315	2.00	17.00	3,768,864	9,000,000	5	5	2

4.4 Test III

The purpose of Test III was to verify the effects of KC-10 and KC-135 availability on Q score and average 24 hour offload. All variables are held constant from Test II with the exception of KC-10 and KC-135 MOG (see Appendix C). The MOGs for both tankers were changed to verify the effect of MOG on tanker availability, offload, and Q scores. Table 6 shows the results of the test. Results returned for the beddown bases are consistent with expectations. Beddown bases with higher numbers of tanker aircraft available have lower Q scores and higher average 24 hour offloads.

Table 6. Goal Programming Results for Test III

H2 ='User Inputs'!H2:H3

Aircraft UTE Goal	Max Sorties Goal	Average 24 hour Offload Goal	Fuel Availability Goal	KC-10 MOG Goal	KC-135 MOG Goal	Threat Goal
3	45	3,000,000	9,000,000	5	14	1

UTE Weight	Max Sorties Goal	Offload Weight	Fuel Weight	KC-10 MOG Weight	KC-135 MOG Weight	Threat Weight
w1-	w2-	w3-	w6-	w4-	w5-	w7+
0.14	0.14	0.15	0.15	0.14	0.14	0.14

	Potential Beddown	Q Score	Aircraft UTE Rate (sorties per day)	Max Sorties (per Day)	Average 24 hour Offload	Fuel Availability	KC-10 Available	KC-135 Available	Threat
1	ALI AL SALEM	1.0000	2.00	0.00	0	9,000,000	0	0	2
2	ALI AL SALEM	0.5798	2.00	6.80	1,594,809	9,000,000	2	2	2
3	ALI AL SALEM	0.5798	2.00	6.80	1,594,809	9,000,000	2	2	2
4	ALI AL SALEM	0.4913	2.00	10.20	2,392,213	9,000,000	3	3	2
5	ALI AL SALEM	0.4124	2.00	13.60	3,189,618	9,000,000	4	4	2
6	ALI AL SALEM	0.3432	2.00	20.40	3,902,017	9,000,000	5	6	2
7	ALI AL SALEM	0.7238	2.00	1.70	351,310	9,000,000	0	1	2
8	ALI AL SALEM	0.7011	2.00	1.70	446,094	9,000,000	1	0	2
9	ALI AL SALEM	0.5798	2.00	6.80	1,594,809	9,000,000	2	2	2
10	ALI AL SALEM	0.3485	2.00	18.70	3,902,017	9,000,000	5	6	2

Figure 13 shows the relationship between the number of tanker aircraft available and Q scores. Beddown base 1 has no KC-10s or KC-135s available, an average 24 hour offload of 0 pounds, and receives a Q score of 1. Beddown bases 2, 3, and 9 have equal numbers of tanker aircrafts available, equal average 24 hour offloads, and equal Q scores. Beddown bases 6 and 10 have equal Q scores, average 24 hours offloads, and equal numbers of tanker aircraft available, but have different KC-10 MOGs. Beddown base 6 has a KC-10 MOG of 6 (see Appendix C), but because the tanker population for this test is restricted to five, beddown base 6's outputs are based off a maximum of five KC-10s.

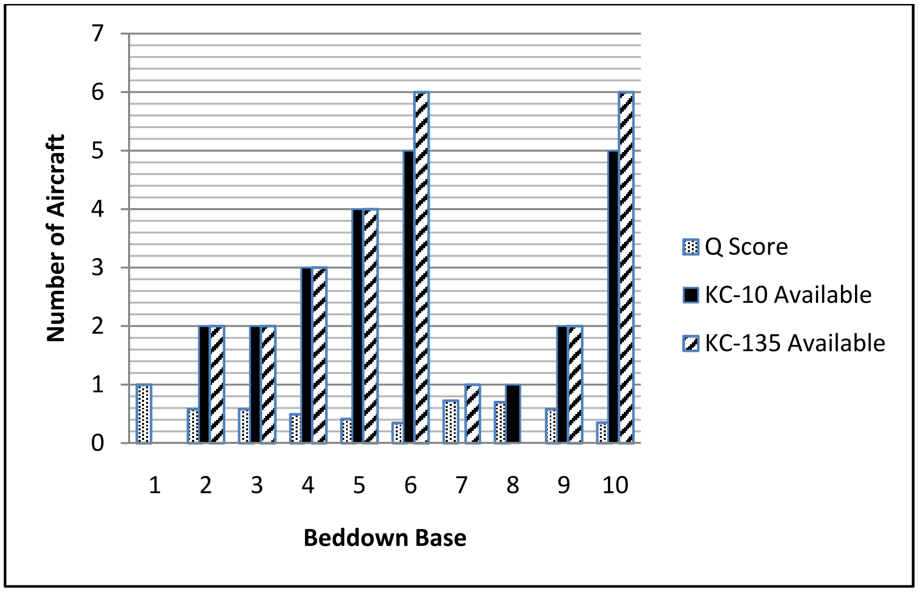

Figure 13. Test III Q Scores Compared to KC-10 and KC-135 MOG

Figure 14 displays the relationship between number of tanker aircraft available and the average 24 hour offload for a beddown base. If the fuel availability is not a constraint, distances are equal, and takeoff weights are equal for all bases then a higher availability of tanker aircraft will result in a higher average 24 hour offload. In almost all foreseeable situations beddown bases will not have equal characteristics, but for this test equal characteristics are required to verify the affect of tanker availability on the Tanker Beddown Model.

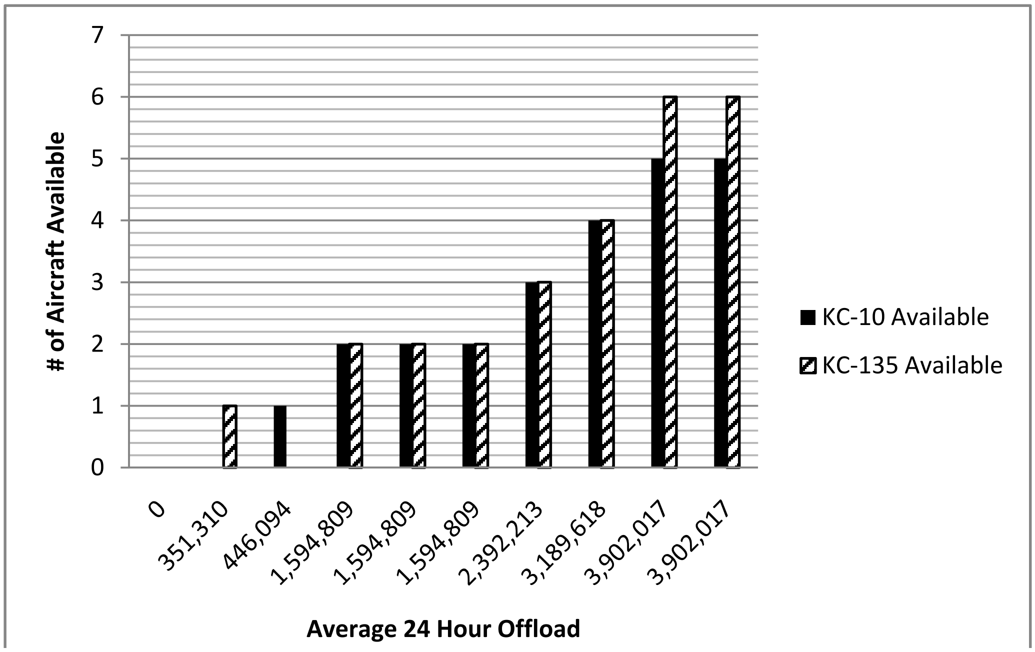

Figure 14. Test III Average 24 Hour Offload Compared to Aircraft Available

4.5 Test IV

The purpose of Test IV was to verify that the Tanker Beddown Model can assist planners in making a multiple-criteria decision. For this test ten different beddown bases and ten different refuel tracks were selected. All other user inputs were based off methods described in chapter 3 (see Appendix D). Table 7 shows the results of the model. Q scores range from as low as 0.100 for Al Udeid AB to as high as 1.0 for three beddown bases that returned negative values for average 24 hour offload. Q scores for this test were determined by the five weighted variables; average 24 hour offload, fuel availability, KC-10 availability, KC-135 availability, and threat. Trends when comparing Q scores to the different variables in the model remain consistent with previous tests. The deviations (see Table 8) from the target goal for these five variables were compared to the Q score for each beddown base to ensure valid results.

Table 7. Goal Programming Results for Test IV

	Aircraft UTE Goal	Max Sorties Goal	Average 24 hour Offload Goal	Fuel Availability Goal	KC-10 MOG Goal	KC-135 MOG Goal	Threat Goal		
	3	45	3,000,000	12,000,000	5	14	1		
	UTE Weight	Max Sorties Goal	Offload Weight	Fuel Weight	KC-10 MOG Weight	KC-135 MOG Weight	Threat Weight		
	w1-	w2-	w3-	w6-	w4-	w5-	w7+		
	0	0	0.4	0.25	0.15	0.1	0.1		
	Potential Beddown	Q Score	Aircraft UTE Rate (sorties per day)	Max Sorties (per Day)	Average 24 hour Offload	Fuel Availability	KC-10 Available	KC-135 Available	Threat
1	ALI AL SALEM AB	0.2006	2.58	30.64	3,281,374	9,981,000	4	10	2
2	Kuwait	0.3412	3.53	57.08	1,764,980	8,324,229	5	14	2
3	Baghdad INTL	0.3578	3.31	30.99	3,706,042	8,263,463	4	7	3
4	KANDAHAR INTL	0.5946	2.01	13.63	1,743,012	7,069,581	3	5	3
5	THUMRAIT	0.1438	2.38	38.41	4,002,998	9,899,876	5	14	2
6	Al Udeid	0.1000	3.92	63.23	4,094,854	12,208,179	5	14	2
7	RAMSTEIN AB	0.5487	1.81	13.81	323,815	9,507,610	2	7	1
8	ROTA NS	1.0000	1.76	19.43	-481,909	9,079,737	2	11	1
9	ALTUS AFB	1.0000	0.64	10.37	-2,837,098	9,475,126	5	11	1
10	LAKENHEATH	1.0000	1.28	20.73	-955,786	9,061,690	5	14	1

Table 8. Test IV Deviations

		Average 24 Hour Offload		KC-10 MOG		KC-135 MOG		Fuel Availability		Threat	
Potential Beddown	Q Score	d3+	d3-	d4+	d4-	d5+	d5-	d6+	d6-	d7+	d7-
Al Udeid	0.1000	1,094,854	0	0	0	0	0	208,179	0	1	0
THUMRAIT	0.1438	1,002,998	0	0	0	0	0	0	2,100,124	1	0
ALI AL SALEM AB	0.2006	281,374	0	0	1	0	4	0	2,019,000	1	0
Kuwait International	0.3412	0	1,235,020	0	0	0	0	0	3,675,771	1	0
Baghdad INTL	0.3578	706,042	0	0	1	0	7	0	3,736,537	2	0
RAMSTEIN AB	0.5487	0	2,676,185	0	3	0	7	0	2,492,390	0	0
KANDAHAR INTL	0.5946	0	1,256,988	0	2	0	9	0	4,930,419	2	0
ROTA NS	1.0000	0	3,481,909	0	3	0	3	0	2,920,263	0	0
ALTUS AFB	1.0000	0	5,837,098	0	0	0	3	0	2,524,874	0	0
LAKENHEATH	1.0000	0	3,955,786	0	0	0	0	0	2,938,310	0	0

Al Udeid AB returned the lowest Q score of 0.1. Inspection of the deviations from the target goals shows that Al Udeid AB exceeded all goals with the exception of threat (see Table 8). Comparing Al Udeid's deviation to the threat goal and the other beddown bases deviations, four potential beddown bases meet the goal and two deviated from the goal by a value larger than Al Udeid. Ramstein AB, Rota NS, Altus AFB, and

Lakenheath AFB are the four bases that exceed the threat goal. Of the four bases only Ramstein AFB returns a positive offload value. The other three bases are penalized with a Q score of 1.0. The lower Q score returned for Al Udeid AB can be validated by the failure of Ramstein AFB to meet or exceed the target goals for 1) average 24 hour offload, 2) KC-10 Availability, 3) KC-135 availability, and 4) fuel availability.

Thumrait returned the second lowest Q score (see Table 8). Thumrait meet or exceeded all target goals with the exception of fuel availability and threat. The second lowest Q score returned for Thumrait is consistent with Al Udeid only exceeding the target goal for threat. Also both Al Udeid and Thumrait missed the threat goal by the equal amounts. Comparing Thumrait to the remaining beddown bases also shows that the second lowest Q score is justified. All of the remaining potential beddown bases fail to meet or exceed at least one more goal than Thumrait. Ali Al Salem has the next lowest Q score, but fails to meet or exceed goals for 1) KC-10 available, 2) KC-135 available, 3) fuel available, and 4) threat.

Ali Al Salem AB failed to meet or exceed four target goals and returned the third lowest Q score even though Kuwait International returned the fourth lowest Q score, but only failed to meet or exceed the three target goals. Both Ali Al Salem and Kuwait International failed to meet or exceed the target goals for 1) fuel availability and 2) threat. The deviation from the threat goal was the same for each base, but Kuwait International missed the fuel availability goal by 3,675,771 pounds more than Ali Al Salem. Ali Al Salem failed to meet the target goals for KC-10 availability and KC-135 availability, but was still able to meet the target goal for fuel offload. Kuwait International met the goal for both KC-10 availability and KC-135 availability, but failed to meet the fuel offload goal. Further inspection of the model reveals that Kuwait International had the capability to offload 4,442,528 pounds per day more fuel than Ali Al Salem, but the average 24 hour offload capacity for Kuwait International was constrained by the amount of fuel available. Kuwait International only has 8,324,229 pounds of fuel available daily. Tanker offload capacity was also constrained at Al Udeid AB and Thumrait, but the daily fuel available was large enough to allow both potential beddown bases to meet or exceed the offload goal.

Potential Beddown	Tanker Offload Capacity	Daily Fuel Availability
Al Udeid	8,252,091	12,208,179
THUMRAIT	4,045,639	9,899,876
ALI AL SALEM AB	1,730,402	9,981,000
Kuwait International	7,702,902	8,324,229
Baghdad INTL	4,589,639	8,263,463
RAMSTEIN AB	323,815	9,507,610
KANDAHAR INTL	1,743,012	7,069,581
ROTA NS	-481,909	9,079,737
ALTUS AFB	-2,837,098	9,475,126
LAKENHEATH	-955,786	9,061,690

Figure 15. Test IV Tanker Offload Capacity and Daily Fuel Availability

Baghdad International returned the fifth lowest Q score. Baghdad International failed to meet or exceed the target goals for 1) KC-10 availability, 2) KC-135 availability, 3) fuel availability, and 4) threat. Comparing Baghdad International to Kuwait International shows that Baghdad International missed the fuel availability goal by 3,736,537 pounds of fuel less than Kuwait International. The capacity for fuel availability for Baghdad International exceeded Kuwait International, but the threat level and tanker availability for Baghdad International offsets any reduction in Q score from fuel availability.

The remaining potential beddown bases either failed to meet or exceed at least four goals or returned a Q score of 1.0 due to a negative average 24 hour offload value. The two remaining potential beddown bases that do not have a Q score of 1.0 are Ramstein AB and Kandahar International. Ramstein AB failed to meet or exceed four goals while Kandahar International failed to meet or exceed five goals.

4.6 Test V

The purpose of Test V was to change the user inputs from Test IV to stress the model and compare changes in the Q score between the two tests. For this test the following changes were made to the user inputs.

1) Al Udeid AB KC-10 MOG changed to 0
2) Altus AFB KC-10 and KC-135 MOG changed to 50
3) Altus AFB fuel availability to 50,000,000
4) Thumrait threat level changed to 3
5) Kuwait International threat level changed to 1

Table 9. Goal Programming Results for Test V

Aircraft UTE Goal	Max Sorties Goal	Average 24 hour Offload Goal	Fuel Availability Goal	KC-10 MOG Goal	KC-135 MOG Goal	Threat Goal
3	45	3,000,000	12,000,000	5	14	1

UTE Weight	Max Sorties Goal	Offload Weight	Fuel Weight	KC-10 MOG Weight	KC-135 MOG Weight	Threat Weight
w1-	w2-	w3-	w6-	w4-	w5-	w7+
0	0	0.4	0.25	0.15	0.1	0.1

	Potential Beddown	Q Score	Aircraft UTE Rate (sorties per day)	Max Sorties (per Day)	Average 24 hour Offload	Fuel Availability	KC-10 Available	KC-135 Available	Threat
1	ALI AL SALEM AB	0.2006	2.58	30.64	3,281,374	9,981,000	4	10	2
2	Kuwait International	0.2412	3.53	57.08	1,764,980	8,324,229	5	14	1
3	Baghdad INTL	0.3578	3.31	30.99	3,706,042	8,263,463	4	7	3
4	KANDAHAR INTL	0.5946	2.01	13.63	1,743,012	7,069,581	3	5	3
5	THUMRAIT	0.2438	2.38	38.41	4,002,998	9,899,876	5	14	3
6	Al Udeid	0.2500	3.92	46.59	3,665,032	12,208,179	0	14	2
7	RAMSTEIN AB	0.5487	1.81	13.81	323,815	9,507,610	2	7	1
8	ROTA NS	1.0000	1.76	19.43	-481,909	9,079,737	2	11	1
9	ALTUS AFB	1.0000	0.64	10.37	-2,837,098	50,000,000	5	14	1
10	LAKENHEATH	1.0000	1.28	20.73	-955,786	9,061,690	5	14	1

Table 9 shows the results for the model after running it with the stated changes. With the changes Al Udeid AB is now the fourth optimal potential beddown base. The loss of 5 KC-10s at Al Udeid reduced the average 24 hour offload by 429,822 pounds and increased the Q score by 0.15 (see Table 10). Kuwait International has the third highest offload amount of the potential beddown bases, but with the decreased threat level it returned the lowest Q score. The Q score returned for Thumrait AB increased by 0.1 and returned the third lowest Q score due to the decreased offload and increased Q score of Al Udeid and no changes to Ali Al Salem AB. Three inputs for Altus AFB were changed, but due to a negative value for average 24 hour offload there is no change to Q score.

Table 10. Changes in Q Scores Between Test IV and V

Potential Beddown	Test IV Q Scores	Test V Q Scores	Difference
Al Udeid	0.1000	0.2500	0.15
Thumrait AB	0.1438	0.2438	0.1
Ali Al Salem AB	0.2006	0.2006	No Change
Kuwait INTL	0.3412	0.2412	-0.1
Baghdad INTL	0.3578	0.3578	No Change
Ramstein AB	0.5487	0.5487	No Change
Kandahar INTL	0.5946	0.5946	No Change
Rota NS	1.0000	1.0000	No Change
Altus AFB	1.0000	1.0000	No Change
Lakenheath AB	1.0000	1.0000	No Change

V. Conclusions and Recommendations

5.1 Introduction

This chapter discusses conclusions produced by this research and provides suggestions for future research.

5.2 Conclusions

Tanker planners will always have to contend with multiple competing goals and limited resources when planning for tanker operations. This research does not capture all factors that influence beddown decision and does not fully model others. But by combining research conducted by MacDonald and Sere, the Tanker Beddown Model provides a rough cut capability to tanker planners to be utilized during the initial planning phases. The model allows planners to quickly quantify performance trade-offs between numerous beddown bases taking into account multiple goals. Results from the model do not have the accuracy or fidelity to be used to conduct operations, but do allow planners to quickly determine optimal solutions and effects of alternate decisions on operations.

Based on user inputs and weighting of the factors, multiple runs of the model will produce different optimal solutions. Tests IV and V showed the models ability to provide the user with quantifiable results to assist in determining optimal decision and to provide different solutions. This ensures the user is able to tailor the model to meet different situations and changes in priorities. However, these tests also show an interdependency between the following factors 1) average 24 hour offload, 2) KC-10 availability, 3) KC-135 availability, and 4) fuel availability. Users need to be aware of the interdependency when assigning weights to ensure solutions returned truly match the user's goals. In Test

V Al Udeid returned the third lowest Q score and maybe viewed as a suitable solution based only off Q score. With a KC-10 availability of zero this is probably not a feasible solution. The weighted averages for average 24 hour offload and fuel availability must be reduced from 0.4 to 0.2 and the weighted average for KC-10 availability increased from 0.15 to 0.35 to reduce Al Udeid AB from third lowest to fourth lowest. The extreme manipulation of the weighted averages result in skewing the Q scores for all beddown bases.

Another weakness of the model is the linear scale used to score the threat level. The linear scale results in equal increases or decreases in the Q score for changes in the threat level. Table 11 displays the Q score differences resulting from changing the threat level for each potential beddown base in Test II. All variables remained the same for Test II with the exception of the threat level. For each increase of one in threat level the Q score increased by 0.14. Depending on how the threat level is defined by the user, the increase from a threat level of two to three may have a greater affect on beddown decisions than an increase from a threat level of one to two.

Table 11. Changes in Q Scores Between Test IV and Five

Potential Beddown	Q Score	Threat	Q Score Difference
ALI AL SALEM AB	0.0915	1	0.0000
ALI AL SALEM AB	0.2315	2	0.1400
ALI AL SALEM AB	0.3715	3	0.1400
ALI AL SALEM AB	0.5115	4	0.1400
ALI AL SALEM AB	0.6515	5	0.1400
ALI AL SALEM AB	0.7915	6	0.1400
ALI AL SALEM AB	0.9315	7	0.1400
ALI AL SALEM AB	1.0715	8	0.1400
ALI AL SALEM AB	1.2115	9	0.1400
ALI AL SALEM AB	1.3515	10	0.1400

5.3 Recommendations for Future Research

This research focused on prior research conducted by Major MacDonald and Captain Sere. While the Tanker Beddown Model takes into account multiple goals and performs numerous calculations, the complexity of tanker planning has not been fully captured. Multiple assumptions, simplifications, and dependency on user inputs have been used to make this model. In order to improve this model and make it more realistic future research should focus on the following:

1) Expand the model to calculate aircraft takeoff fuel loads
2) Expand the model to allow the user to calculate average sortie duration
3) Expand the model to include aircrew utilization rates
4) Allow the user to input limits and constraints to identify infeasible solutions and prevent them from influencing Q scores
5) Compare this model with current tanker planning tools and adjust inputs and outputs to complement existing planning tools
6) Add visual basic code to enhance the user interface with the model
7) Update the model to add the future Air Force Tanker

Appendix A. Test I Excel Worksheets

User Inputs Worksheet

Aircraft UTE Goal	Max Sorties Goal	Average 24 hour Offload Goal	Fuel Availability Goal	KC-10 MOG Goal	KC-135 MOG Goal	Threat Goal	
3	25	3,000,000	9,000,000	5	5	1	
UTE Weight	**Max Sorties Goal**	**Offload Weight**	**Fuel Weight**	**KC-10 MOG Weight**	**KC-135 MOG Weight**	**Threat Weight**	**Weight Sum**
0.14	0.14	0.15	0.15	0.14	0.14	0.14	1

Location

	Potential Beddown	Latitude	North/South (N/S)	Longitude	East /West (E/W)	KC-10 MOG	KC-135 MOG	Daily Fuel Availability	Threat Level	Average Sortie Duration	Aircraft Turn Time
1	ALI AL SALEM AB	29.21	N	47.31998	E	5	5	9000000	2	6.00	6.00
2	Kuwait International	29.226567	N	47.968928	E	5	5	9000000	2	6.00	6.00
3	Baghdad INTL	33.16002	N	44.13998	E	5	5	9000000	2	6.00	6.00
4	KANDAHAR INTL	31.3	N	65.51	E	5	5	9000000	2	6.00	6.00
5	THUMRAIT	17.40002	N	54.01002	E	5	5	9000000	2	6.00	6.00
6	Al Udeid	25.0702	N	51.1854	E	5	5	9000000	2	6.00	6.00
7	RAMSTEIN AB	49.25998	N	7.36	E	5	5	9000000	2	6.00	6.00
8	ROTA NS	36.39	N	6.21	W	5	5	9000000	2	6.00	6.00
9	ALTUS AFB	34.40002	N	99.16002	W	5	5	9000000	2	6.00	6.00
10	LAKENHEATH	52.25002	N	0.34002	W	5	5	9000000	2	6.00	6.00

	Potential Beddown	KC-10 Takeoff Fuel Load	KC-135R/T Takeoff Fuel Load	KC-135E Takeoff Fuel Load	KC-10 Destination Reserve	KC-135R/T Destination Reserve	KC-135E Destination Reserve	KC-10 Average Airspeed	KC-135R/T Average Airspeed	KC-135E Average Airspeed
1	ALI AL SALEM AB	327000	200000	160000	70000	70000	70000	450	439	439
2	Kuwait International	327000	200000	160000	70000	70000	70000	450	439	439
3	Baghdad INTL	327000	200000	160000	70000	70000	70000	450	439	439
4	KANDAHAR INTL	327000	200000	160000	70000	70000	70000	450	439	439
5	THUMRAIT	327000	200000	160000	70000	70000	70000	450	439	439
6	Al Udeid	327000	200000	160000	70000	70000	70000	450	439	439
7	RAMSTEIN AB	327000	200000	160000	70000	70000	70000	450	439	439
8	ROTA NS	327000	200000	160000	70000	70000	70000	450	439	439
9	ALTUS AFB	327000	200000	160000	70000	70000	70000	450	439	439
10	LAKENHEATH	327000	200000	160000	70000	70000	70000	450	439	439

Aircraft Information

	Number Available	Ground Spares Required	Maintenance Reliability	Fuel Flow (lbs per hr)
KC-10	5	1	85	17830
KC-135 R/T	4	1	85	10718
KC-135E	10	1	85	12000
Total	19	3	85.00	

	Refuel Points	Latitude		Longitude	
1	Mosul	36.2838	N	42.8629	E
2	Anbar	32.7886	N	41.9995	E
3	Kuwait	29.7875	N	47.2766	E
4	Turkey	38.3890	N	41.3699	E
5	Saudi Arabia	25.3322	N	44.3681	E
6	Yemen	13.4500	N	43.3046	E
7	Diyala	33.3527	N	45.2379	E
8	An Najaf	31.6030	N	44.6593	E
9	Saudi Arabia 2	30.4970	N	40.0607	E
10	Red Sea	22.3518	N	37.4703	E

Average Receiver Aircraft

Receiver Daily Sortie Count	50

Results Worksheet

Aircraft UTE Goal	Max Sorties Goal	Average 24 hour Offload Goal	Fuel Availability Goal	KC-10 MOG Goal	KC-135 MOG Goal	Threat Goal
3	25	3000000	9000000	5	5	1

UTE Weight	Max Sorties Goal	Offload Weight	Fuel Weight	KC-10 MOG Weight	KC-135 MOG Weight	Threat Weight
w1-	w2-	w3-	w6-	w4-	w5-	w7+
0.14	0.14	0.15	0.15	0.14	0.14	0.14

	Potential Beddown	Q Score	Aircraft UTE Rate (sorties per day)	Max Sorties (per Day)	Average 24 hour Offload	Fuel Availability	KC-10 Available	KC-135 Available	Threat
1	ALI AL SALEM AB	0.2315	2.00	17.00	3,768,864	9,000,000	5	5	2
2	Kuwait International	0.2315	2.00	17.00	3,711,063	9,000,000	5	5	2
3	Baghdad INTL	0.2315	2.00	17.00	3,882,201	9,000,000	5	5	2
4	KANDAHAR INTL	0.2627	2.00	17.00	2,375,514	9,000,000	5	5	2
5	THUMRAIT	0.2433	2.00	17.00	2,763,645	9,000,000	5	5	2
6	Al Udeid	0.2315	2.00	17.00	3,381,961	9,000,000	5	5	2
7	RAMSTEIN AB	0.3303	2.00	17.00	1,022,970	9,000,000	5	5	2
8	ROTA NS	0.3736	2.00	17.00	157,078	9,000,000	5	5	2
9	ALTUS AFB	1.0000	2.00	17.00	-6,536,351	9,000,000	5	5	2
10	LAKENHEATH	0.3603	2.00	17.00	422,444	9,000,000	5	5	2

Deviation Values from Results Worksheet

Aircraft UTE Goal	Max Sorties Goal	Average 24 hour Offload Goal	Fuel Availability Goal	KC-10 MOG Goal	KC-135 MOG Goal	Threat Goal
3	25	3000000	9000000	5	5	1

UTE Weight	Max Sorties Goal	Offload Weight	Fuel Weight	KC-10 MOG Weight	KC-135 MOG Weight	Threat Weight
w1-	w2-	w3-	w6-	w4-	w5-	w7+
0.14	0.14	0.15	0.15	0.14	0.14	0.14

			UTE Rate		Max Sorties		Offload	KC-10 MOG	KC-135 MOG	Fuel Availability		Threat				
	Potential Beddown	Q Score	d1+	d1-	d2+	d2-	d3+	d3-	d4+	d4-	d5+	d5-	d6+	d6-	d7+	d7-
1	ALI AL SALEM AB	0.2315	0.00	1.00	0.00	8.00	768,864	0	0	0	0	0	0	0	1	0
2	Kuwait International	0.2315	0.00	1.00	0.00	8.00	711,063	0	0	0	0	0	0	0	1	0
3	Baghdad INTL	0.2315	0.00	1.00	0.00	8.00	882,201	0	0	0	0	0	0	0	1	0
4	KANDAHAR INTL	0.2627	0.00	1.00	0.00	8.00	0	624,486	0	0	0	0	0	0	1	0
5	THUMRAIT	0.2433	0.00	1.00	0.00	8.00	0	236,355	0	0	0	0	0	0	1	0
6	Al Udeid	0.2315	0.00	1.00	0.00	8.00	381,961	0	0	0	0	0	0	0	1	0
7	RAMSTEIN AB	0.3303	0.00	1.00	0.00	8.00	0	1,977,030	0	0	0	0	0	0	1	0
8	ROTA NS	0.3736	0.00	1.00	0.00	8.00	0	2,842,922	0	0	0	0	0	0	1	0
9	ALTUS AFB	1.0000	0.00	1.00	0.00	8.00	0	9,536,351	0	0	0	0	0	0	1	0
10	LAKENHEATH	0.3603	0.00	1.00	0.00	8.00	0	2,577,556	0	0	0	0	0	0	1	0

Distance Calculator Worksheet

	Potential Beddown Location	Latitude		Longitude							
1	ALI AL SALEM AB	29.21000	N	47.31998	E	29.21000	-47.31998	29.35000	47.53330	29.35000	-47.53330
2	Kuwait International	29.22657	N	47.96893	E	29.22657	-47.96893	29.37761	48.61488	29.37761	-48.61488
3	Baghdad INTL	33.16002	N	44.13998	E	33.16002	-44.13998	33.26670	44.23330	33.26670	-44.23330
4	KANDAHAR INTL	31.30000	N	65.51000	E	31.30000	-65.51000	31.50000	65.85000	31.50000	-65.85000
5	THUMRAIT	17.40002	N	54.01002	E	17.40002	-54.01002	17.66670	54.01670	17.66670	-54.01670
6	Al Udeid	25.07020	N	51.18540	E	25.07020	-51.18540	25.11700	51.30900	25.11700	-51.30900
7	RAMSTEIN AB	49.25998	N	7.36000	E	49.25998	-7.36000	49.43330	7.60000	49.43330	-7.60000
8	ROTA NS	36.39000	N	6.21000	W	36.39000	6.21000	36.65000	6.35000	36.65000	6.35000
9	ALTUS AFB	34.40002	N	99.16002	W	34.40002	99.16002	34.66670	99.26670	34.66670	99.26670
10	LAKENHEATH	52.25002	N	0.34002	W	52.25002	0.34002	52.41670	0.56670	52.41670	0.56670

	Refuel Points	Latitude		Longitude							
1	Mosul	36.28380	N	42.86290	E	36.28380	-42.86290	36.47300	43.43817	36.47300	-43.43817
2	Anbar	32.78860	N	41.99950	E	32.78860	-41.99950	33.31433	42.66583	33.31433	-42.66583
3	Kuwait	29.78750	N	47.27660	E	29.78750	-47.27660	30.31250	47.46100	30.31250	-47.46100
4	Turkey	38.38900	N	41.36990	E	38.38900	-41.36990	38.64833	41.61650	38.64833	-41.61650
5	Saudi Arabia	25.33220	N	44.36810	E	25.33220	-44.36810	25.55367	44.61350	25.55367	-44.61350
6	Yemen	13.45000	N	43.30460	E	13.45000	-43.30460	13.75000	43.50767	13.75000	-43.50767
7	Diyala	33.35270	N	45.23790	E	33.35270	-45.23790	33.58783	45.39650	33.58783	-45.39650
8	An Najaf	31.60300	N	44.65930	E	31.60300	-44.65930	32.00500	45.09883	32.00500	-45.09883
9	Saudi Arabia 2	30.49700	N	40.06070	E	30.49700	-40.06070	30.82833	40.10117	30.82833	-40.10117
10	Red Sea	22.35180	N	37.47030	E	22.35180	-37.47030	22.58633	37.78383	22.58633	-37.78383

Distance Calculations

Refuel Points

Beddown Location	Mosul	Anbar	Kuwait	Turkey	Saudi Arabia	Yemen	Diyala	An Najaf	Saudi Arabia 2	Red Sea	AVERAGE	Total Distance Round Trip Distance
ALI AL SALEM AB	474	345	58	630	276	962	277	203	396	664	428	857
Kuwait International	499	386	82	656	313	980	302	240	450	712	462	924
Baghdad INTL	196	79	242	347	463	1172	61	87	256	726	363	726
KANDAHAR INTL	1151	1177	948	1260	1173	1626	1040	1058	1320	1587	1234	2468
THUMRAIT	1260	1120	839	1416	706	651	1062	987	1095	960	1010	2019
Al Udeid	792	668	373	949	364	812	595	527	685	757	652	1304
RAMSTEIN AB	1734	1827	2129	1586	2234	2772	1918	1971	1839	2150	2016	4032
ROTA NS	2371	2392	2685	2256	2669	2993	2515	2534	2321	2427	2516	5033
ALTUS AFB	6050	6193	6471	5894	6644	7204	6248	6323	6249	6583	6386	12772
LAKENHEATH	2072	2174	2474	1921	2588	3127	2260	2316	2193	2505	2363	4726

UTE Calculator Worksheet

		Aircraft Cycle	Aircraft UTE Rate (sorties per day)	Tanker Sorties Required	Aircraft Required	Max Sorties per Day	Maximum Aircraft Available
1	ALI AL SALEM AB	12.00	2.00	8.93	8.78	17.00	10.00
2	Kuwait International	12.00	2.00	8.93	8.78	17.00	10.00
3	Baghdad INTL	12.00	2.00	8.93	8.78	17.00	10.00
4	KANDAHAR INTL	12.00	2.00	8.93	8.78	17.00	10.00
5	THUMRAIT	12.00	2.00	8.93	8.78	17.00	10.00
6	Al Udeid	12.00	2.00	8.93	8.78	17.00	10.00
7	RAMSTEIN AB	12.00	2.00	8.93	8.78	17.00	10.00
8	ROTA NS	12.00	2.00	8.93	8.78	17.00	10.00
9	ALTUS AFB	12.00	2.00	8.93	8.78	17.00	10.00
10	LAKENHEATH	12.00	2.00	8.93	8.78	17.00	10.00

Offload Calculator Worksheet

Potential Beddown	KC-10 Average Offload per Sortie	KC-135R Average Offload per sortie	KC-135E Average Offload per Sortie	Average Offload per Sortie
ALI AL SALEM AB	223,047	109,079	66,576	132,901
Kuwait International	220,399	107,447	64,750	130,865
Baghdad INTL	228,239	112,278	70,158	136,892
KANDAHAR INTL	159,215	69,746	22,539	83,834
THUMRAIT	176,996	80,703	34,806	97,502
Al Udeid	205,322	98,157	54,348	119,276
RAMSTEIN AB	97,252	31,566	-20,208	36,203
ROTA NS	57,584	7,123	-47,575	5,711
ALTUS AFB	-249,055	-181,823	-259,121	-230,000
LAKENHEATH	69,741	14,614	-39,188	15,056

Potential Beddown	KC-10 Average 24 hour Offload	KC-135R Average 24 hour Offload	KC-135 Average 24 hour Offload	Average 24 hour Offload
ALI AL SALEM AB	2,230,471	872,630	665,763	3,768,864
Kuwait International	2,203,991	859,577	647,495	3,711,063
Baghdad INTL	2,282,393	898,225	701,584	3,882,201
KANDAHAR INTL	1,592,149	557,971	225,394	2,375,514
THUMRAIT	1,769,960	645,623	348,063	2,763,645
Al Udeid	2,053,223	785,256	543,482	3,381,961
RAMSTEIN AB	972,522	252,528	-202,079	1,022,970
ROTA NS	575,839	56,984	-475,745	157,078
ALTUS AFB	-2,490,555	-1,454,586	-2,591,210	-6,536,351
LAKENHEATH	697,409	116,911	-391,876	422,444

Potential Beddown	KC-10 Tanker Generation	KC-135R Tanker Generation	KC-135E Tanker Generation
ALI AL SALEM AB	10	8	10
Kuwait International	10	8	10
Baghdad INTL	10	8	10
KANDAHAR INTL	10	8	10
THUMRAIT	10	8	10
Al Udeid	10	8	10
RAMSTEIN AB	10	8	10
ROTA NS	10	8	10
ALTUS AFB	10	8	10
LAKENHEATH	10	8	10

Appendix B. Test II Excel Worksheets

User Inputs Worksheet

Aircraft UTE Goal	Max Sorties Goal	Average 24 hour Offload Goal	Fuel Availability Goal	KC-10 MOG Goal	KC-135 MOG Goal	Threat Goal	
3	25	3,000,000	9,000,000	5	5	1	
UTE Weight	**Max Sorties Goal**	**Offload Weight**	**Fuel Weight**	**KC-10 MOG Weight**	**KC-135 MOG Weight**	**Threat Weight**	**Weight Sum**
0.14	0.14	0.15	0.15	0.14	0.14	0.14	1

Location

	Potential Beddown	Latitude	North/South (N/S)	Longitude	East /West (E/W)	KC-10 MOG	KC-135 MOG	Daily Fuel Availability	Threat Level	Average Sortie Duration	Aircraft Turn Time
1	ALI AL SALEM AB	29.21	N	47.31998	E	5	5	9000000	2	6.00	6.00
2	ALI AL SALEM AB	29.21	N	47.31998	E	5	5	9000000	2	6.00	6.00
3	ALI AL SALEM AB	29.21	N	47.31998	E	5	5	9000000	2	6.00	6.00
4	ALI AL SALEM AB	29.21	N	47.31998	E	5	5	9000000	2	6.00	6.00
5	ALI AL SALEM AB	29.21	N	47.31998	E	5	5	9000000	2	6.00	6.00
6	ALI AL SALEM AB	29.21	N	47.31998	E	5	5	9000000	2	6.00	6.00
7	ALI AL SALEM AB	29.21	N	47.31998	E	5	5	9000000	2	6.00	6.00
8	ALI AL SALEM AB	29.21	N	47.31998	E	5	5	9000000	2	6.00	6.00
9	ALI AL SALEM AB	29.21	N	47.31998	E	5	5	9000000	2	6.00	6.00
10	ALI AL SALEM AB	29.21	N	47.31998	E	5	5	9000000	2	6.00	6.00

	Potential Beddown	KC-10 Takeoff Fuel Load	KC-135R/T Takeoff Fuel Load	KC-135E Takeoff Fuel Load	KC-10 Destination Reserve	KC-135R/T Destination Reserve	KC-135E Destination Reserve	KC-10 Average Airspeed	KC-135R/T Average Airspeed	KC-135E Average Airspeed
1	ALI AL SALEM AB	327000	200000	160000	70000	70000	70000	450	439	439
2	ALI AL SALEM AB	327000	200000	160000	70000	70000	70000	450	439	439
3	ALI AL SALEM AB	327000	200000	160000	70000	70000	70000	450	439	439
4	ALI AL SALEM AB	327000	200000	160000	70000	70000	70000	450	439	439
5	ALI AL SALEM AB	327000	200000	160000	70000	70000	70000	450	439	439
6	ALI AL SALEM AB	327000	200000	160000	70000	70000	70000	450	439	439
7	ALI AL SALEM AB	327000	200000	160000	70000	70000	70000	450	439	439
8	ALI AL SALEM AB	327000	200000	160000	70000	70000	70000	450	439	439
9	ALI AL SALEM AB	327000	200000	160000	70000	70000	70000	450	439	439
10	ALI AL SALEM AB	327000	200000	160000	70000	70000	70000	450	439	439

Aircraft Information

	Number Available	Ground Spares Required	Maintenance Reliability	Fuel Flow (lbs per hr)
KC-10	5	1	85	17830
KC-135 R/T	4	1	85	10718
KC-135E	10	1	85	12000
Total	19	3	85.00	

	Refuel Points	Latitude		Longitude	
1	Mosul	36.2838	N	42.8629	E
2	Anbar	32.7886	N	41.9995	E
3	Kuwait	29.7875	N	47.2766	E
4	Turkey	38.3890	N	41.3699	E
5	Saudi Arabia	25.3322	N	44.3681	E
6	Yemen	13.4500	N	43.3046	E
7	Diyala	33.3527	N	45.2379	E
8	An Najaf	31.6030	N	44.6593	E
9	Saudi Arabia 2	30.4970	N	40.0607	E
10	Red Sea	22.3518	N	37.4703	E

Average Receiver Aircraft

Receiver Daily Sortie Count	50

Results Worksheet

Aircraft UTE Goal	Max Sorties Goal	Average 24 hour Offload Goal	Fuel Availability Goal	KC-10 MOG Goal	KC-135 MOG Goal	Threat Goal
3	25	3000000	9000000	5	5	1

UTE Weight	Max Sorties Goal	Offload Weight	Fuel Weight	KC-10 MOG Weight	KC-135 MOG Weight	Threat Weight
w1-	w2-	w3-	w6-	w4-	w5-	w7+
0.14	0.14	0.15	0.15	0.14	0.14	0.14

	Potential Beddown	Q Score	Aircraft UTE Rate (sorties per day)	Max Sorties (per Day)	Average 24 hour Offload	Fuel Availability	KC-10 Available	KC-135 Available	Threat
1	ALI AL SALEM AB	0.2315	2.00	17.00	3,768,864	9,000,000	5	5	2
2	ALI AL SALEM AB	0.2315	2.00	17.00	3,768,864	9,000,000	5	5	2
3	ALI AL SALEM AB	0.2315	2.00	17.00	3,768,864	9,000,000	5	5	2
4	ALI AL SALEM AB	0.2315	2.00	17.00	3,768,864	9,000,000	5	5	2
5	ALI AL SALEM AB	0.2315	2.00	17.00	3,768,864	9,000,000	5	5	2
6	ALI AL SALEM AB	0.2315	2.00	17.00	3,768,864	9,000,000	5	5	2
7	ALI AL SALEM AB	0.2315	2.00	17.00	3,768,864	9,000,000	5	5	2
8	ALI AL SALEM AB	0.2315	2.00	17.00	3,768,864	9,000,000	5	5	2
9	ALI AL SALEM AB	0.2315	2.00	17.00	3,768,864	9,000,000	5	5	2
10	ALI AL SALEM AB	0.2315	2.00	17.00	3,768,864	9,000,000	5	5	2

Deviation Values from Results Worksheet

Aircraft UTE Goal	Max Sorties Goal	Average 24 hour Offload Goal	Fuel Availability Goal	KC-10 MOG Goal	KC-135 MOG Goal	Threat Goal
3	25	3000000	9000000	5	5	1

UTE Weight	Max Sorties Goal	Offload Weight	Fuel Weight	KC-10 MOG Weight	KC-135 MOG Weight	Threat Weight
w1-	w2-	w3-	w6-	w4-	w5-	w7+
0.14	0.14	0.15	0.15	0.14	0.14	0.14

			UTE Rate		Max Sorties		Offload		KC-10 MOG		KC-135 MOG		Fuel Availability		Threat	
	Potential Beddown	Q Score	d1+	d1-	d2+	d2-	d3+	d3-	d4+	d4-	d5+	d5-	d6+	d6-	d7+	d7-
1	ALI AL SALEM AB	0.2315	0.00	1.00	0.00	8.00	768,864	0	0	0	0	0	0	0	1	0
2	ALI AL SALEM AB	0.2315	0.00	1.00	0.00	8.00	768,864	0	0	0	0	0	0	0	1	0
3	ALI AL SALEM AB	0.2315	0.00	1.00	0.00	8.00	768,864	0	0	0	0	0	0	0	1	0
4	ALI AL SALEM AB	0.2315	0.00	1.00	0.00	8.00	768,864	0	0	0	0	0	0	0	1	0
5	ALI AL SALEM AB	0.2315	0.00	1.00	0.00	8.00	768,864	0	0	0	0	0	0	0	1	0
6	ALI AL SALEM AB	0.2315	0.00	1.00	0.00	8.00	768,864	0	0	0	0	0	0	0	1	0
7	ALI AL SALEM AB	0.2315	0.00	1.00	0.00	8.00	768,864	0	0	0	0	0	0	0	1	0
8	ALI AL SALEM AB	0.2315	0.00	1.00	0.00	8.00	768,864	0	0	0	0	0	0	0	1	0
9	ALI AL SALEM AB	0.2315	0.00	1.00	0.00	8.00	768,864	0	0	0	0	0	0	0	1	0
10	ALI AL SALEM AB	0.2315	0.00	1.00	0.00	8.00	768,864	0	0	0	0	0	0	0	1	0

Distance Calculator Worksheet

	Potential Beddown Location	Latitude		Longitude							
1	ALI AL SALEM AB	29.21000	N	47.31998	E	29.21000	-47.31998	29.35000	47.53330	29.35000	-47.53330
2	ALI AL SALEM AB	29.21000	N	47.31998	E	29.21000	-47.31998	29.35000	47.53330	29.35000	-47.53330
3	ALI AL SALEM AB	29.21000	N	47.31998	E	29.21000	-47.31998	29.35000	47.53330	29.35000	-47.53330
4	ALI AL SALEM AB	29.21000	N	47.31998	E	29.21000	-47.31998	29.35000	47.53330	29.35000	-47.53330
5	ALI AL SALEM AB	29.21000	N	47.31998	E	29.21000	-47.31998	29.35000	47.53330	29.35000	-47.53330
6	ALI AL SALEM AB	29.21000	N	47.31998	E	29.21000	-47.31998	29.35000	47.53330	29.35000	-47.53330
7	ALI AL SALEM AB	29.21000	N	47.31998	E	29.21000	-47.31998	29.35000	47.53330	29.35000	-47.53330
8	ALI AL SALEM AB	29.21000	N	47.31998	E	29.21000	-47.31998	29.35000	47.53330	29.35000	-47.53330
9	ALI AL SALEM AB	29.21000	N	47.31998	E	29.21000	-47.31998	29.35000	47.53330	29.35000	-47.53330
10	ALI AL SALEM AB	29.21000	N	47.31998	E	29.21000	-47.31998	29.35000	47.53330	29.35000	-47.53330

	Refuel Points	Latitude		Longitude							
1	Mosul	36.28380	N	42.86290	E	36.28380	-42.86290	36.47300	43.43817	36.47300	-43.43817
2	Anbar	32.78860	N	41.99950	E	32.78860	-41.99950	33.31433	42.66583	33.31433	-42.66583
3	Kuwait	29.78750	N	47.27660	E	29.78750	-47.27660	30.31250	47.46100	30.31250	-47.46100
4	Turkey	38.38900	N	41.36990	E	38.38900	-41.36990	38.64833	41.61650	38.64833	-41.61650
5	Saudi Arabia	25.33220	N	44.36810	E	25.33220	-44.36810	25.55367	44.61350	25.55367	-44.61350
6	Yemen	13.45000	N	43.30460	E	13.45000	-43.30460	13.75000	43.50767	13.75000	-43.50767
7	Diyala	33.35270	N	45.23790	E	33.35270	-45.23790	33.58783	45.39650	33.58783	-45.39650
8	An Najaf	31.60300	N	44.65930	E	31.60300	-44.65930	32.00500	45.09883	32.00500	-45.09883
9	Saudi Arabia 2	30.49700	N	40.06070	E	30.49700	-40.06070	30.82833	40.10117	30.82833	-40.10117
10	Red Sea	22.35180	N	37.47030	E	22.35180	-37.47030	22.58633	37.78383	22.58633	-37.78383

Distance Calculations

Refuel Points

Beddown Location	Mosul	Anbar	Kuwait	Turkey	Saudi Arabia	Yemen	Diyala	An Najaf	Saudi Arabia 2	Red Sea	AVERAGE	Total Distance Round Trip Distance
ALI AL SALEM AB	474	345	58	630	276	962	277	203	396	664	428	857
ALI AL SALEM AB	474	345	58	630	276	962	277	203	396	664	428	857
ALI AL SALEM AB	474	345	58	630	276	962	277	203	396	664	428	857
ALI AL SALEM AB	474	345	58	630	276	962	277	203	396	664	428	857
ALI AL SALEM AB	474	345	58	630	276	962	277	203	396	664	428	857
ALI AL SALEM AB	474	345	58	630	276	962	277	203	396	664	428	857
ALI AL SALEM AB	474	345	58	630	276	962	277	203	396	664	428	857
ALI AL SALEM AB	474	345	58	630	276	962	277	203	396	664	428	857
ALI AL SALEM AB	474	345	58	630	276	962	277	203	396	664	428	857
ALI AL SALEM AB	474	345	58	630	276	962	277	203	396	664	428	857

UTE Calculator Worksheet

		Aircraft Cycle	Aircraft UTE Rate (sorties per day)	Tanker Sorties Required	Aircraft Required	Max Sorties per Day	Maximum Aircraft Available
1	ALI AL SALEM AB	12.00	2.00	8.93	8.78	17.00	10.00
2	ALI AL SALEM AB	12.00	2.00	8.93	8.78	17.00	10.00
3	ALI AL SALEM AB	12.00	2.00	8.93	8.78	17.00	10.00
4	ALI AL SALEM AB	12.00	2.00	8.93	8.78	17.00	10.00
5	ALI AL SALEM AB	12.00	2.00	8.93	8.78	17.00	10.00
6	ALI AL SALEM AB	12.00	2.00	8.93	8.78	17.00	10.00
7	ALI AL SALEM AB	12.00	2.00	8.93	8.78	17.00	10.00
8	ALI AL SALEM AB	12.00	2.00	8.93	8.78	17.00	10.00
9	ALI AL SALEM AB	12.00	2.00	8.93	8.78	17.00	10.00
10	ALI AL SALEM AB	12.00	2.00	8.93	8.78	17.00	10.00

Offload Calculator Worksheet

Potential Beddown	KC-10 Average Offload per Sortie	KC-135R Average Offload per sortie	KC-135E Average Offload per Sortie	Average Offload per Sortie
ALI AL SALEM AB	223,047	109,079	66,576	132,901
ALI AL SALEM AB	223,047	109,079	66,576	132,901
ALI AL SALEM AB	223,047	109,079	66,576	132,901
ALI AL SALEM AB	223,047	109,079	66,576	132,901
ALI AL SALEM AB	223,047	109,079	66,576	132,901
ALI AL SALEM AB	223,047	109,079	66,576	132,901
ALI AL SALEM AB	223,047	109,079	66,576	132,901
ALI AL SALEM AB	223,047	109,079	66,576	132,901
ALI AL SALEM AB	223,047	109,079	66,576	132,901
ALI AL SALEM AB	223,047	109,079	66,576	132,901

Potential Beddown	KC-10 Average 24 hour Offload	KC-135R Average 24 hour Offload	KC-135 Average 24 hour Offload	Average 24 hour Offload
ALI AL SALEM AB	2,230,471	872,630	665,763	3,768,864
ALI AL SALEM AB	2,230,471	872,630	665,763	3,768,864
ALI AL SALEM AB	2,230,471	872,630	665,763	3,768,864
ALI AL SALEM AB	2,230,471	872,630	665,763	3,768,864
ALI AL SALEM AB	2,230,471	872,630	665,763	3,768,864
ALI AL SALEM AB	2,230,471	872,630	665,763	3,768,864
ALI AL SALEM AB	2,230,471	872,630	665,763	3,768,864
ALI AL SALEM AB	2,230,471	872,630	665,763	3,768,864
ALI AL SALEM AB	2,230,471	872,630	665,763	3,768,864
ALI AL SALEM AB	2,230,471	872,630	665,763	3,768,864

Potential Beddown	KC-10 Tanker Generation	KC-135R Tanker Generation	KC-135E Tanker Generation
ALI AL SALEM AB	10	8	10
ALI AL SALEM AB	10	8	10
ALI AL SALEM AB	10	8	10
ALI AL SALEM AB	10	8	10
ALI AL SALEM AB	10	8	10
ALI AL SALEM AB	10	8	10
ALI AL SALEM AB	10	8	10
ALI AL SALEM AB	10	8	10
ALI AL SALEM AB	10	8	10
ALI AL SALEM AB	10	8	10

Appendix C. Test III Excel Worksheets

User Inputs Worksheet

Aircraft UTE Goal	Max Sorties Goal	Average 24 hour Offload Goal	Fuel Availability Goal	KC-10 MOG Goal	KC-135 MOG Goal	Threat Goal	
3	45	3,000,000	9,000,000	5	14	1	
UTE Weight	**Max Sorties Goal**	**Offload Weight**	**Fuel Weight**	**KC-10 MOG Weight**	**KC-135 MOG Weight**	**Threat Weight**	**Weight Sum**
0.14	0.14	0.15	0.15	0.14	0.14	0.14	1

Location

	Potential Beddown	Latitude	North/South (N/S)	Longitude	East /West (E/W)	KC-10 MOG	KC-135 MOG	Daily Fuel Availability	Threat Level	Average Sortie Duration	Aircraft Turn Time
1	ALI AL SALEM AB	29.21	N	47.31998	E	0	0	9000000	2	6.00	6.00
2	ALI AL SALEM AB	29.21	N	47.31998	E	2	2	9000000	2	6.00	6.00
3	ALI AL SALEM AB	29.21	N	47.31998	E	2	2	9000000	2	6.00	6.00
4	ALI AL SALEM AB	29.21	N	47.31998	E	3	3	9000000	2	6.00	6.00
5	ALI AL SALEM AB	29.21	N	47.31998	E	4	4	9000000	2	6.00	6.00
6	ALI AL SALEM AB	29.21	N	47.31998	E	6	6	9000000	2	6.00	6.00
7	ALI AL SALEM AB	29.21	N	47.31998	E	0	1	9000000	2	6.00	6.00
8	ALI AL SALEM AB	29.21	N	47.31998	E	1	0	9000000	2	6.00	6.00
9	ALI AL SALEM AB	29.21	N	47.31998	E	2	2	9000000	2	6.00	6.00
10	ALI AL SALEM AB	29.21	N	47.31998	E	5	6	9000000	2	6.00	6.00

	Potential Beddown	KC-10 Takeoff Fuel Load	KC-135R/T Takeoff Fuel Load	KC-135E Takeoff Fuel Load	KC-10 Destination Reserve	KC-135R/T Destination Reserve	KC-135E Destination Reserve	KC-10 Average Airspeed	KC-135R/T Average Airspeed	KC-135E Average Airspeed
1	ALI AL SALEM AB	327000	200000	160000	70000	70000	70000	450	439	439
2	ALI AL SALEM AB	327000	200000	160000	70000	70000	70000	450	439	439
3	ALI AL SALEM AB	327000	200000	160000	70000	70000	70000	450	439	439
4	ALI AL SALEM AB	327000	200000	160000	70000	70000	70000	450	439	439
5	ALI AL SALEM AB	327000	200000	160000	70000	70000	70000	450	439	439
6	ALI AL SALEM AB	327000	200000	160000	70000	70000	70000	450	439	439
7	ALI AL SALEM AB	327000	200000	160000	70000	70000	70000	450	439	439
8	ALI AL SALEM AB	327000	200000	160000	70000	70000	70000	450	439	439
9	ALI AL SALEM AB	327000	200000	160000	70000	70000	70000	450	439	439
10	ALI AL SALEM AB	327000	200000	160000	70000	70000	70000	450	439	439

Aircraft Information

	Number Available	Ground Spares Required	Maintenance Reliability	Fuel Flow (lbs per hr)
KC-10	5	1	85	17830
KC-135 R/T	4	1	85	10718
KC-135E	10	1	85	12000
Total	19	3	85.00	

	Refuel Points	Latitude		Longitude	
1	Mosul	36.2838	N	42.8629	E
2	Anbar	32.7886	N	41.9995	E
3	Kuwait	29.7875	N	47.2766	E
4	Turkey	38.3890	N	41.3699	E
5	Saudi Arabia	25.3322	N	44.3681	E
6	Yemen	13.4500	N	43.3046	E
7	Diyala	33.3527	N	45.2379	E
8	An Najaf	31.6030	N	44.6593	E
9	Saudi Arabia 2	30.4970	N	40.0607	E
10	Red Sea	22.3518	N	37.4703	E

Average Receiver Aircraft	
Receiver Daily Sortie Count	50

Results Worksheet

Aircraft UTE Goal	Max Sorties Goal	Average 24 hour Offload Goal	Fuel Availability Goal	KC-10 MOG Goal	KC-135 MOG Goal	Threat Goal
3	45	3,000,000	9,000,000	5	14	1
UTE Weight	**Max Sorties Goal**	**Offload Weight**	**Fuel Weight**	**KC-10 MOG Weight**	**KC-135 MOG Weight**	**Threat Weight**
w1-	w2-	w3-	w6-	w4-	w5-	w7+
0.14	0.14	0.15	0.15	0.14	0.14	0.14

	Potential Beddown	Q Score	Aircraft UTE Rate (sorties per day)	Max Sorties (per Day)	Average 24 hour Offload	Fuel Availability	KC-10 Availabl e	KC-135 Availabl e	Threa t
1	ALI AL SALEM AB	1.0000	2.00	0.00	0	9,000,000	0	0	2
2	ALI AL SALEM AB	0.5798	2.00	6.80	1,594,809	9,000,000	2	2	2
3	ALI AL SALEM AB	0.5798	2.00	6.80	1,594,809	9,000,000	2	2	2
4	ALI AL SALEM AB	0.4913	2.00	10.20	2,392,213	9,000,000	3	3	2
5	ALI AL SALEM AB	0.4124	2.00	13.60	3,189,618	9,000,000	4	4	2
6	ALI AL SALEM AB	0.3432	2.00	20.40	3,902,017	9,000,000	5	6	2
7	ALI AL SALEM AB	0.7238	2.00	1.70	351,310	9,000,000	0	1	2
8	ALI AL SALEM AB	0.7011	2.00	1.70	446,094	9,000,000	1	0	2
9	ALI AL SALEM AB	0.5798	2.00	6.80	1,594,809	9,000,000	2	2	2
10	ALI AL SALEM AB	0.3485	2.00	18.70	3,902,017	9,000,000	5	6	2

Deviation Values from Results Worksheet

Aircraft UTE Goal	Max Sorties Goal	Average 24 hour Offload Goal	Fuel Availability Goal	KC-10 MOG Goal	KC-135 MOG Goal	Threat Goal
3	45	3,000,000	9,000,000	5	14	1
UTE Weight	**Max Sorties Goal**	**Offload Weight**	**Fuel Weight**	**KC-10 MOG Weight**	**KC-135 MOG Weight**	**Threat Weight**
w1-	w2-	w3-	w6-	w4-	w5-	w7+
0.14	0.14	0.15	0.15	0.14	0.14	0.14

			UTE Rate		Max Sorties		Offload		KC-10 MOG		KC-135 MOG		Fuel Availability		Threat	
	Potential Beddown	**Q Score**	**d1+**	**d1-**	**d2+**	**d2-**	**d3+**	**d3-**	**d4+**	**d4-**	**d5+**	**d5-**	**d6+**	**d6-**	**d7+**	**d7-**
1	ALI AL SALEM AB	1.0000	0.00	1.00	0.00	45.00	0	3,000,000	0	5	0	14	0	0	1	0
2	ALI AL SALEM AB	0.5798	0.00	1.00	0.00	38.20	0	1,405,191	0	3	0	12	0	0	1	0
3	ALI AL SALEM AB	0.5798	0.00	1.00	0.00	38.20	0	1,405,191	0	3	0	12	0	0	1	0
4	ALI AL SALEM AB	0.4913	0.00	1.00	0.00	34.80	0	607,787	0	2	0	11	0	0	1	0
5	ALI AL SALEM AB	0.4124	0.00	1.00	0.00	31.40	189,618	0	0	1	0	10	0	0	1	0
6	ALI AL SALEM AB	0.3432	0.00	1.00	0.00	24.60	902,017	0	0	0	0	8	0	0	1	0
7	ALI AL SALEM AB	0.7238	0.00	1.00	0.00	43.30	0	2,648,690	0	5	0	13	0	0	1	0
8	ALI AL SALEM AB	0.7011	0.00	1.00	0.00	43.30	0	2,553,906	0	4	0	14	0	0	1	0
9	ALI AL SALEM AB	0.5798	0.00	1.00	0.00	38.20	0	1,405,191	0	3	0	12	0	0	1	0
10	ALI AL SALEM AB	0.3485	0.00	1.00	0.00	26.30	902,017	0	0	0	0	8	0	0	1	0

Distance Calculator Worksheet

	Potential Beddown Location	Latitude		Longitude							
1	ALI AL SALEM AB	29.21000	N	47.31998	E	29.21000	-47.31998	29.35000	47.53330	29.35000	-47.53330
2	ALI AL SALEM AB	29.21000	N	47.31998	E	29.21000	-47.31998	29.35000	47.53330	29.35000	-47.53330
3	ALI AL SALEM AB	29.21000	N	47.31998	E	29.21000	-47.31998	29.35000	47.53330	29.35000	-47.53330
4	ALI AL SALEM AB	29.21000	N	47.31998	E	29.21000	-47.31998	29.35000	47.53330	29.35000	-47.53330
5	ALI AL SALEM AB	29.21000	N	47.31998	E	29.21000	-47.31998	29.35000	47.53330	29.35000	-47.53330
6	ALI AL SALEM AB	29.21000	N	47.31998	E	29.21000	-47.31998	29.35000	47.53330	29.35000	-47.53330
7	ALI AL SALEM AB	29.21000	N	47.31998	E	29.21000	-47.31998	29.35000	47.53330	29.35000	-47.53330
8	ALI AL SALEM AB	29.21000	N	47.31998	E	29.21000	-47.31998	29.35000	47.53330	29.35000	-47.53330
9	ALI AL SALEM AB	29.21000	N	47.31998	E	29.21000	-47.31998	29.35000	47.53330	29.35000	-47.53330
10	ALI AL SALEM AB	29.21000	N	47.31998	E	29.21000	-47.31998	29.35000	47.53330	29.35000	-47.53330

	Refuel Points	Latitude		Longitude							
1	Mosul	36.28380	N	42.86290	E	36.28380	-42.86290	36.47300	43.43817	36.47300	-43.43817
2	Anbar	32.78860	N	41.99950	E	32.78860	-41.99950	33.31433	42.66583	33.31433	-42.66583
3	Kuwait	29.78750	N	47.27660	E	29.78750	-47.27660	30.31250	47.46100	30.31250	-47.46100
4	Turkey	38.38900	N	41.36990	E	38.38900	-41.36990	38.64833	41.61650	38.64833	-41.61650
5	Saudi Arabia	25.33220	N	44.36810	E	25.33220	-44.36810	25.55367	44.61350	25.55367	-44.61350
6	Yemen	13.45000	N	43.30460	E	13.45000	-43.30460	13.75000	43.50767	13.75000	-43.50767
7	Diyala	33.35270	N	45.23790	E	33.35270	-45.23790	33.58783	45.39650	33.58783	-45.39650
8	An Najaf	31.60300	N	44.65930	E	31.60300	-44.65930	32.00500	45.09883	32.00500	-45.09883
9	Saudi Arabia 2	30.49700	N	40.06070	E	30.49700	-40.06070	30.82833	40.10117	30.82833	-40.10117
10	Red Sea	22.35180	N	37.47030	E	22.35180	-37.47030	22.58633	37.78383	22.58633	-37.78383

Distance Calculations

Refuel Points

Beddown Location	Mosul	Anbar	Kuwait	Turkey	Saudi Arabia	Yemen	Diyala	An Najaf	Saudi Arabia 2	Red Sea	AVERAGE	Total Distance Round Trip Distance
ALI AL SALEM AB	474	345	58	630	276	962	277	203	396	664	428	857
ALI AL SALEM AB	474	345	58	630	276	962	277	203	396	664	428	857
ALI AL SALEM AB	474	345	58	630	276	962	277	203	396	664	428	857
ALI AL SALEM AB	474	345	58	630	276	962	277	203	396	664	428	857
ALI AL SALEM AB	474	345	58	630	276	962	277	203	396	664	428	857
ALI AL SALEM AB	474	345	58	630	276	962	277	203	396	664	428	857
ALI AL SALEM AB	474	345	58	630	276	962	277	203	396	664	428	857
ALI AL SALEM AB	474	345	58	630	276	962	277	203	396	664	428	857
ALI AL SALEM AB	474	345	58	630	276	962	277	203	396	664	428	857
ALI AL SALEM AB	474	345	58	630	276	962	277	203	396	664		

UTE Calculator Worksheet

		Aircraft Cycle	Aircraft UTE Rate (sorties per day)	Tanker Sorties Required	Aircraft Required	Max Sorties per Day	Maximum Aircraft Available
1	ALI AL SALEM AB	12.00	2.00	12.50	10.88	0.00	0.00
2	ALI AL SALEM AB	12.00	2.00	8.93	8.78	6.80	4.00
3	ALI AL SALEM AB	12.00	2.00	8.93	8.78	6.80	4.00
4	ALI AL SALEM AB	12.00	2.00	8.93	8.78	10.20	6.00
5	ALI AL SALEM AB	12.00	2.00	8.93	8.78	13.60	8.00
6	ALI AL SALEM AB	12.00	2.00	8.93	8.78	20.40	12.00
7	ALI AL SALEM AB	12.00	2.00	12.50	10.88	1.70	1.00
8	ALI AL SALEM AB	12.00	2.00	8.93	8.78	1.70	1.00
9	ALI AL SALEM AB	12.00	2.00	8.93	8.78	6.80	4.00
10	ALI AL SALEM AB	12.00	2.00	8.93	8.78	18.70	11.00

Offload Calculator Worksheet

	Potential Beddown	KC-10 Average Offload per Sortie	KC-135R Average Offload per sortie	KC-135E Average Offload per Sortie	Average Offload per Sortie
1	ALI AL SALEM AB	223,047	109,079	66,576	132,901
2	ALI AL SALEM AB	223,047	109,079	66,576	132,901
3	ALI AL SALEM AB	223,047	109,079	66,576	132,901
4	ALI AL SALEM AB	223,047	109,079	66,576	132,901
5	ALI AL SALEM AB	223,047	109,079	66,576	132,901
6	ALI AL SALEM AB	223,047	109,079	66,576	132,901
7	ALI AL SALEM AB	223,047	109,079	66,576	132,901
8	ALI AL SALEM AB	223,047	109,079	66,576	132,901
9	ALI AL SALEM AB	223,047	109,079	66,576	132,901
10	ALI AL SALEM AB	223,047	109,079	66,576	132,901

	Potential Beddown	KC-10 Average 24 hour Offload	KC-135R Average 24 hour Offload	KC-135 Average 24 hour Offload	Average 24 hour Offload
1	ALI AL SALEM AB	0	0	0	0
2	ALI AL SALEM AB	892,188	436,315	266,305	1,594,809
3	ALI AL SALEM AB	892,188	436,315	266,305	1,594,809
4	ALI AL SALEM AB	1,338,283	654,473	399,458	2,392,213
5	ALI AL SALEM AB	1,784,377	872,630	532,611	3,189,618
6	ALI AL SALEM AB	2,230,471	872,630	798,916	3,902,017
7	ALI AL SALEM AB	0	218,158	133,153	351,310
8	ALI AL SALEM AB	446,094	0	0	446,094
9	ALI AL SALEM AB	892,188	436,315	266,305	1,594,809
10	ALI AL SALEM AB	2,230,471	872,630	798,916	3,902,017

	Potential Beddown	KC-10 Tanker Generation	KC-135R Tanker Generation	KC-135E Tanker Generation
1	ALI AL SALEM AB	0	0	0
2	ALI AL SALEM AB	4	4	4
3	ALI AL SALEM AB	4	4	4
4	ALI AL SALEM AB	6	6	6
5	ALI AL SALEM AB	8	8	8
6	ALI AL SALEM AB	10	8	12
7	ALI AL SALEM AB	0	2	2
8	ALI AL SALEM AB	2	0	0
9	ALI AL SALEM AB	4	4	4
10	ALI AL SALEM AB	10	8	12

Appendix D. Test IV Excel Worksheets

User Inputs Worksheet

Aircraft UTE Goal	Max Sorties Goal	Average 24 hour Offload Goal	Fuel Availability Goal	KC-10 MOG Goal	KC-135 MOG Goal	Threat Goal	
3	45	3,000,000	12,000,000	5	14	1	
UTE Weight	Max Sorties Goal	Offload Weight	Fuel Weight	KC-10 MOG Weight	KC-135 MOG Weight	Threat Weight	Weight Sum
0	0	0.4	0.25	0.15	0.1	0.1	1

Location

	Potential Beddown	Latitude	North/South (N/S)	Longitude	East /West (E/W)	KC-10 MOG	KC-135 MOG	Daily Fuel Availability	Threat Level	Average Sortie Duration	Aircraft Turn Time
1	ALI AL SALEM AB	29.21	N	47.31998	E	4	10	9,981,000	2	3.95	5.37
2	Kuwait International	29.226567	N	47.968928	E	12	14	8,324,229	2	4.10	2.69
3	Baghdad INTL	33.16002	N	44.13998	E	4	7	8,263,463	3	3.65	3.59
4	KANDAHAR INTL	31.3	N	65.51	E	3	5	7,069,581	3	7.62	4.35
5	THUMRAIT	17.40002	N	54.01002	E	9	15	9,899,876	2	6.60	3.49
6	Al Udeid	25.0702	N	51.1854	E	6	14	12,208,179	2	4.97	1.16
7	RAMSTEIN AB	49.25998	N	7.36	E	2	7	9,507,610	1	11.18	2.11
8	ROTA NS	36.39	N	6.21	W	2	11	9,079,737	1	13.46	0.19
9	ALTUS AFB	34.40002	N	99.16002	W	8	11	9,475,126	1	31.09	6.29
10	LAKENHEATH	52.25002	N	0.34002	W	11	14	9,061,690	1	12.76	5.94

	Potential Beddown	KC-10 Takeoff Fuel Load	KC-135R/T Takeoff Fuel Load	KC-135E Takeoff Fuel Load	KC-10 Destination Reserve	KC-135R/T Destination Reserve	KC-135E Destination Reserve	KC-10 Average Airspeed	KC-135R/T Average Airspeed	KC-135E Average Airspeed
1	ALI AL SALEM AB	287000	160000	120000	70000	70000	70000	450	439	439
2	Kuwait International	327000	200000	160000	70000	70000	70000	450	439	439
3	Baghdad INTL	356000	200000	160000	70000	70000	70000	450	439	439
4	KANDAHAR INTL	327000	200000	160000	70000	70000	70000	450	439	439
5	THUMRAIT	356000	200000	160000	70000	70000	70000	450	439	439
6	Al Udeid	356000	200000	160000	70000	70000	70000	450	439	439
7	RAMSTEIN AB	327000	200000	160000	70000	70000	70000	450	439	439
8	ROTA NS	356000	200000	160000	70000	70000	70000	450	439	439
9	ALTUS AFB	356000	200000	160000	70000	70000	70000	450	439	439
10	LAKENHEATH	287000	160000	120000	70000	70000	70000	450	439	439

Aircraft Information

	Number Available	Ground Spares Required	Maintenance Reliability	Fuel Flow (lbs per hr)
KC-10	5	1	85	17830
KC-135 R/T	4	1	85	10718
KC-135E	10	1	85	12000
Total	19	3	85.00	

	Refuel Points	Latitude		Longitude	
1	Mosul	36.2838	N	42.8629	E
2	Anbar	32.7886	N	41.9995	E
3	Kuwait	29.7875	N	47.2766	E
4	Turkey	38.3890	N	41.3699	E
5	Saudi Arabia	25.3322	N	44.3681	E
6	Yemen	13.4500	N	43.3046	E
7	Diyala	33.3527	N	45.2379	E
8	An Najaf	31.6030	N	44.6593	E
9	Saudi Arabia 2	30.4970	N	40.0607	E
10	Red Sea	22.3518	N	37.4703	E

Average Receiver Aircraft

Receiver Daily Sortie Count	50

Results Worksheet

Aircraft UTE Goal	Max Sorties Goal	Average 24 hour Offload Goal	Fuel Availability Goal	KC-10 MOG Goal	KC-135 MOG Goal	Threat Goal
3	45	3,000,000	12,000,000	5	14	1
UTE Weight	**Max Sorties Goal**	**Offload Weight**	**Fuel Weight**	**KC-10 MOG Weight**	**KC-135 MOG Weight**	**Threat Weight**
w1-	w2-	w3-	w6-	w4-	w5-	w7+
0	0	0.4	0.25	0.15	0.1	0.1

	Potential Beddown	Q Score	Aircraft UTE Rate (sorties per day)	Max Sorties (per Day)	Average 24 hour Offload	Fuel Availability	KC-10 Available	KC-135 Available	Threat
1	ALI AL SALEM AB	0.2006	2.58	30.64	3,281,374	9,981,000	4	10	2
2	Kuwait International	0.3412	3.53	57.08	1,764,980	8,324,229	5	14	2
3	Baghdad INTL	0.3578	3.31	30.99	3,706,042	8,263,463	4	7	3
4	KANDAHAR INTL	0.5946	2.01	13.63	1,743,012	7,069,581	3	5	3
5	THUMRAIT	0.1438	2.38	38.41	4,002,998	9,899,876	5	14	2
6	Al Udeid	0.1000	3.92	63.23	4,094,854	12,208,179	5	14	2
7	RAMSTEIN AB	0.5487	1.81	13.81	323,815	9,507,610	2	7	1
8	ROTA NS	1.0000	1.76	19.43	-481,909	9,079,737	2	11	1
9	ALTUS AFB	1.0000	0.64	10.37	-2,837,098	9,475,126	5	11	1
10	LAKENHEATH	1.0000	1.28	20.73	-955,786	9,061,690	5	14	1

Deviation Values from Results Worksheet

Aircraft UTE Goal	Max Sorties Goal	Average 24 hour Offload Goal	Fuel Availability Goal	KC-10 MOG Goal	KC-135 MOG Goal	Threat Goal
3	45	3,000,000	12,000,000	5	14	1
UTE Weight	**Max Sorties Goal**	**Offload Weight**	**Fuel Weight**	**KC-10 MOG Weight**	**KC-135 MOG Weight**	**Threat Weight**
w1-	w2-	w3-	w6-	w4-	w5-	w7+
0	0	0.4	0.25	0.15	0.1	0.1

			UTE Rate		Max Sorties		Offload		KC-10 MOG		KC-135 MOG		Fuel Availability		Threat	
	Potential Beddown	Q Score	d1+	d1-	d2+	d2-	d3+	d3-	d4+	d4-	d5+	d5-	d6+	d6-	d7+	d7-
1	ALI AL SALEM AB	0.2006	0.00	0.42	0.00	14.36	281,374	0	0	1	0	4	0	2,019,000	1	0
2	Kuwait International	0.3412	0.53	0.00	12.08	0.00	0	1,235,020	0	0	0	0	0	3,675,771	1	0
3	Baghdad INTL	0.3578	0.31	0.00	0.00	14.01	706,042	0	0	1	0	7	0	3,736,537	2	0
4	KANDAHAR INTL	0.5946	0.00	0.99	0.00	31.37	0	1,256,988	0	2	0	9	0	4,930,419	2	0
5	THUMRAIT	0.1438	0.00	0.62	0.00	6.59	1,002,998	0	0	0	0	0	0	2,100,124	1	0
6	Al Udeid	0.1000	0.92	0.00	18.23	0.00	1,094,854	0	0	0	0	0	208,179	0	1	0
7	RAMSTEIN AB	0.5487	0.00	1.19	0.00	31.19	0	2,676,185	0	3	0	7	0	2,492,390	0	0
8	ROTA NS	1.0000	0.00	1.24	0.00	25.57	0	3,481,909	0	3	0	3	0	2,920,263	0	0
9	ALTUS AFB	1.0000	0.00	2.36	0.00	34.63	0	5,837,098	0	0	0	3	0	2,524,874	0	0
10	LAKENHEATH	1.0000	0.00	1.72	0.00	24.27	0	3,955,786	0	0	0	0	0	2,938,310	0	0

Distance Calculator Worksheet

	Potential Beddown Location	Latitude		Longitude							
1	ALI AL SALEM AB	29.21000	N	47.31998	E	29.21000	-47.31998	29.35000	47.53330	29.35000	-47.53330
2	Kuwait International	29.22657	N	47.96893	E	29.22657	-47.96893	29.37761	48.61488	29.37761	-48.61488
3	Baghdad INTL	33.16002	N	44.13998	E	33.16002	-44.13998	33.26670	44.23330	33.26670	-44.23330
4	KANDAHAR INTL	31.30000	N	65.51000	E	31.30000	-65.51000	31.50000	65.85000	31.50000	-65.85000
5	THUMRAIT	17.40002	N	54.01002	E	17.40002	-54.01002	17.66670	54.01670	17.66670	-54.01670
6	Al Udeid	25.07020	N	51.18540	E	25.07020	-51.18540	25.11700	51.30900	25.11700	-51.30900
7	RAMSTEIN AB	49.25998	N	7.36000	E	49.25998	-7.36000	49.43330	7.60000	49.43330	-7.60000
8	ROTA NS	36.39000	N	6.21000	W	36.39000	6.21000	36.65000	6.35000	36.65000	6.35000
9	ALTUS AFB	34.40002	N	99.16002	W	34.40002	99.16002	34.66670	99.26670	34.66670	99.26670
10	LAKENHEATH	52.25002	N	0.34002	W	52.25002	0.34002	52.41670	0.56670	52.41670	0.56670

	Refuel Points	Latitude		Longitude							
1	Mosul	36.28380	N	42.86290	E	36.28380	-42.86290	36.47300	43.43817	36.47300	-43.43817
2	Anbar	32.78860	N	41.99950	E	32.78860	-41.99950	33.31433	42.66583	33.31433	-42.66583
3	Kuwait	29.78750	N	47.27660	E	29.78750	-47.27660	30.31250	47.46100	30.31250	-47.46100
4	Turkey	38.38900	N	41.36990	E	38.38900	-41.36990	38.64833	41.61650	38.64833	-41.61650
5	Saudi Arabia	25.33220	N	44.36810	E	25.33220	-44.36810	25.55367	44.61350	25.55367	-44.61350
6	Yemen	13.45000	N	43.30460	E	13.45000	-43.30460	13.75000	43.50767	13.75000	-43.50767
7	Diyala	33.35270	N	45.23790	E	33.35270	-45.23790	33.58783	45.39650	33.58783	-45.39650
8	An Najaf	31.60300	N	44.65930	E	31.60300	-44.65930	32.00500	45.09883	32.00500	-45.09883
9	Saudi Arabia 2	30.49700	N	40.06070	E	30.49700	-40.06070	30.82833	40.10117	30.82833	-40.10117
10	Red Sea	22.35180	N	37.47030	E	22.35180	-37.47030	22.58633	37.78383	22.58633	-37.78383

Distance Calculations

Refuel Points

Beddown Location	Mosul	Anbar	Kuwait	Turkey	Saudi Arabia	Yemen	Diyala	An Najaf	Saudi Arabia 2	Red Sea	AVERAGE	Total Distance Round Trip Distance
ALI AL SALEM AB	474	345	58	630	276	962	277	203	396	664	428	857
Kuwait International	499	386	82	656	313	980	302	240	450	712	462	924
Baghdad INTL	196	79	242	347	463	1172	61	87	256	726	363	726
KANDAHAR INTL	1151	1177	948	1260	1173	1626	1040	1058	1320	1587	1234	2468
THUMRAIT	1260	1120	839	1416	706	651	1062	987	1095	960	1010	2019
Al Udeid	792	668	373	949	364	812	595	527	685	757	652	1304
RAMSTEIN AB	1734	1827	2129	1586	2234	2772	1918	1971	1839	2150	2016	4032
ROTA NS	2371	2392	2685	2256	2669	2993	2515	2534	2321	2427	2516	5033
ALTUS AFB	6050	6193	6471	5894	6644	7204	6248	6323	6249	6583	6386	12772
LAKENHEATH	2072	2174	2474	1921	2588	3127	2260	2316	2193	2505	2363	4726

UTE Calculator Worksheet

		Aircraft Cycle	Aircraft UTE Rate (sorties per day)	Tanker Sorties Required	Aircraft Required	Max Sorties per Day	Maximum Aircraft Available
1	ALI AL SALEM AB	9.32	2.58	8.93	7.61	30.64	14.00
2	Kuwait International	6.79	3.53	8.93	6.50	57.08	19.00
3	Baghdad INTL	7.24	3.31	8.93	6.70	30.99	11.00
4	KANDAHAR INTL	11.97	2.01	8.93	8.77	13.63	8.00
5	THUMRAIT	10.09	2.38	8.93	7.95	38.41	19.00
6	Al Udeid	6.13	3.92	8.93	6.21	63.23	19.00
7	RAMSTEIN AB	13.29	1.81	8.93	9.35	13.81	9.00
8	ROTA NS	13.65	1.76	8.93	9.50	19.43	13.00
9	ALTUS AFB	37.38	0.64	8.93	19.89	10.37	19.00
10	LAKENHEATH	18.70	1.28	8.93	11.71	20.73	19.00

Offload Calculator Worksheet

	Potential Beddown	KC-10 Average Offload per Sortie	KC-135R Average Offload per sortie	KC-135E Average Offload per Sortie	Average Offload per Sortie
1	ALI AL SALEM AB	183,047	69,079	26,576	92,901
2	Kuwait International	220,399	107,447	64,750	130,865
3	Baghdad INTL	257,239	112,278	70,158	146,559
4	KANDAHAR INTL	159,215	69,746	22,539	83,834
5	THUMRAIT	205,996	80,703	34,806	107,168
6	Al Udeid	234,322	98,157	54,348	128,942
7	RAMSTEIN AB	97,252	31,566	-20,208	36,203
8	ROTA NS	86,584	7,123	-47,575	15,377
9	ALTUS AFB	-220,055	-181,823	-259,121	-220,333
10	LAKENHEATH	29,741	-25,386	-79,188	-24,944

	Potential Beddown	KC-10 Average 24 hour Offload	KC-135R Average 24 hour Offload	KC-135 Average 24 hour Offload	Average 24 hour Offload
1	ALI AL SALEM AB	1,885,464	711,541	684,369	3,281,374
2	Kuwait International	3,895,124	1,519,134	2,288,643	7,702,902
3	Baghdad INTL	3,410,908	1,488,770	1,627,984	6,527,662
4	KANDAHAR INTL	957,684	559,370	225,958	1,743,012
5	THUMRAIT	2,449,903	767,836	827,900	4,045,639
6	Al Udeid	4,587,059	1,537,206	2,127,826	8,252,091
7	RAMSTEIN AB	351,249	228,016	-255,450	323,815
8	ROTA NS	304,471	50,096	-836,475	-481,909
9	ALTUS AFB	-706,438	-466,962	-1,663,698	-2,837,098
10	LAKENHEATH	190,850	-130,324	-1,016,312	-955,786

	Potential Beddown	KC-10 Tanker Generation	KC-135R Tanker Generation	KC-135E Tanker Generation
1	ALI AL SALEM AB	10	10	26
2	Kuwait International	18	14	35
3	Baghdad INTL	13	13	23
4	KANDAHAR INTL	6	8	10
5	THUMRAIT	12	10	24
6	Al Udeid	20	16	39
7	RAMSTEIN AB	4	7	13
8	ROTA NS	4	7	18
9	ALTUS AFB	3	3	6
10	LAKENHEATH	6	5	13

Appendix E. Test V Excel Worksheets

User Inputs Worksheet

Aircraft UTE Goal	Max Sorties Goal	Average 24 hour Offload Goal	Fuel Availability Goal	KC-10 MOG Goal	KC-135 MOG Goal	Threat Goal	
3	45	3,000,000	12,000,000	5	14	1	
UTE Weight	Max Sorties Goal	Offload Weight	Fuel Weight	KC-10 MOG Weight	KC-135 MOG Weight	Threat Weight	Weight Sum
0	0	0.4	0.25	0.15	0.1	0.1	1

Location

	Potential Beddown	Latitude	North/South (N/S)	Longitude	East /West (E/W)	KC-10 MOG	KC-135 MOG	Daily Fuel Availability	Threat Level	Average Sortie Duration	Aircraft Turn Time
1	ALI AL SALEM AB	29.21	N	47.31998	E	4	10	9,981,000	2	3.95	5.37
2	Kuwait International	29.226567	N	47.968928	E	12	14	8,324,229	1	4.10	2.69
3	Baghdad INTL	33.16002	N	44.13998	E	4	7	8,263,463	3	3.65	3.59
4	KANDAHAR INTL	31.3	N	65.51	E	3	5	7,069,581	3	7.62	4.35
5	THUMRAIT	17.40002	N	54.01002	E	9	15	9,899,876	3	6.60	3.49
6	Al Udeid	25.0702	N	51.1854	E	0	14	12,208,179	2	4.97	1.16
7	RAMSTEIN AB	49.25998	N	7.36	E	2	7	9,507,610	1	11.18	2.11
8	ROTA NS	36.39	N	6.21	W	2	11	9,079,737	1	13.46	0.19
9	ALTUS AFB	34.40002	N	99.16002	W	50	50	50,000,000	1	31.09	6.29
10	LAKENHEATH	52.25002	N	0.34002	W	11	14	9,061,690	1	12.76	5.94

	Potential Beddown	KC-10 Takeoff Fuel Load	KC-135R/T Takeoff Fuel Load	KC-135E Takeoff Fuel Load	KC-10 Destination Reserve	KC-135R/T Destination Reserve	KC-135E Destination Reserve	KC-10 Average Airspeed	KC-135R/T Average Airspeed	KC-135E Average Airspeed
1	ALI AL SALEM AB	287000	160000	120000	70000	70000	70000	450	439	439
2	Kuwait International	327000	200000	160000	70000	70000	70000	450	439	439
3	Baghdad INTL	356000	200000	160000	70000	70000	70000	450	439	439
4	KANDAHAR INTL	327000	200000	160000	70000	70000	70000	450	439	439
5	THUMRAIT	356000	200000	160000	70000	70000	70000	450	439	439
6	Al Udeid	356000	200000	160000	70000	70000	70000	450	439	439
7	RAMSTEIN AB	327000	200000	160000	70000	70000	70000	450	439	439
8	ROTA NS	356000	200000	160000	70000	70000	70000	450	439	439
9	ALTUS AFB	356000	200000	160000	70000	70000	70000	450	439	439
10	LAKENHEATH	287000	160000	120000	70000	70000	70000	450	439	439

Aircraft Information

	Number Available	Ground Spares Required	Maintenance Reliability	Fuel Flow (lbs per hr)
KC-10	5	1	85	17830
KC-135 R/T	4	1	85	10718
KC-135E	10	1	85	12000
Total	19	3	85.00	

	Refuel Points	Latitude		Longitude	
1	Mosul	36.2838	N	42.8629	E
2	Anbar	32.7886	N	41.9995	E
3	Kuwait	29.7875	N	47.2766	E
4	Turkey	38.3890	N	41.3699	E
5	Saudi Arabia	25.3322	N	44.3681	E
6	Yemen	13.4500	N	43.3046	E
7	Diyala	33.3527	N	45.2379	E
8	An Najaf	31.6030	N	44.6593	E
9	Saudi Arabia 2	30.4970	N	40.0607	E
10	Red Sea	22.3518	N	37.4703	E

Average Receiver Aircraft

Receiver Daily Sortie Count	50

Results Worksheet

Aircraft UTE Goal	Max Sorties Goal	Average 24 hour Offload Goal	Fuel Availability Goal	KC-10 MOG Goal	KC-135 MOG Goal	Threat Goal
3	45	3,000,000	12,000,000	5	14	1
UTE Weight	**Max Sorties Goal**	**Offload Weight**	**Fuel Weight**	**KC-10 MOG Weight**	**KC-135 MOG Weight**	**Threat Weight**
w1-	w2-	w3-	w6-	w4-	w5-	w7+
0	0	0.4	0.25	0.15	0.1	0.1

Potential Beddown	Q Score	Aircraft UTE Rate (sorties per day)	Max Sorties (per Day)	Average 24 hour Offload	Fuel Availability	KC-10 Available	KC-135 Available	Threat
ALI AL SALEM AB	0.2006	2.58	30.64	3,281,374	9,981,000	4	10	2
Kuwait International	0.2412	3.53	57.08	1,764,980	8,324,229	5	14	1
Baghdad INTL	0.3578	3.31	30.99	3,706,042	8,263,463	4	7	3
KANDAHAR INTL	0.5946	2.01	13.63	1,743,012	7,069,581	3	5	3
THUMRAIT	0.2438	2.38	38.41	4,002,998	9,899,876	5	14	3
Al Udeid	0.2500	3.92	46.59	3,665,032	12,208,179	0	14	2
RAMSTEIN AB	0.5487	1.81	13.81	323,815	9,507,610	2	7	1
ROTA NS	1.0000	1.76	19.43	-481,909	9,079,737	2	11	1
ALTUS AFB	1.0000	0.64	10.37	-2,837,098	50,000,000	5	14	1
LAKENHEATH	1.0000	1.28	20.73	-955,786	9,061,690	5	14	1

Deviation Values from Results Worksheet

Aircraft UTE Goal	Max Sorties Goal	Average 24 hour Offload Goal	Fuel Availability Goal	KC-10 MOG Goal	KC-135 MOG Goal	Threat Goal
3	45	3,000,000	12,000,000	5	14	1
UTE Weight	**Max Sorties Goal**	**Offload Weight**	**Fuel Weight**	**KC-10 MOG Weight**	**KC-135 MOG Weight**	**Threat Weight**
w1-	w2-	w3-	w6-	w4-	w5-	w7+
0	0	0.4	0.25	0.15	0.1	0.1

		UTE Rate		Max Sorties		Offload		KC-10 MOG		KC-135 MOG		Fuel Availability		Threat	
Potential Beddown	**Q Score**	**d1+**	**d1-**	**d2+**	**d2-**	**d3+**	**d3-**	**d4+**	**d4-**	**d5+**	**d5-**	**d6+**	**d6-**	**d7+**	**d7-**
ALI AL SALEM AB	0.2006	0.00	0.42	0.00	14.36	281,374	0	0	1	0	4	0	2,019,000	1	0
Kuwait International	0.2412	0.53	0.00	12.08	0.00	0	1,235,020	0	0	0	0	0	3,675,771	0	0
Baghdad INTL	0.3578	0.31	0.00	0.00	14.01	706,042	0	0	1	0	7	0	3,736,537	2	0
KANDAHAR INTL	0.5946	0.00	0.99	0.00	31.37	0	1,256,988	0	2	0	9	0	4,930,419	2	0
THUMRAIT	0.2438	0.00	0.62	0.00	6.59	1,002,998	0	0	0	0	0	0	2,100,124	2	0
Al Udeid	0.2500	0.92	0.00	1.59	0.00	665,032	0	0	5	0	0	208,179	0	1	0
RAMSTEIN AB	0.5487	0.00	1.19	0.00	31.19	0	2,676,185	0	3	0	7	0	2,492,390	0	0
ROTA NS	1.0000	0.00	1.24	0.00	25.57	0	3,481,909	0	3	0	3	0	2,920,263	0	0
ALTUS AFB	1.0000	0.00	2.36	0.00	34.63	0	5,837,098	0	0	0	0	38,000,000	0	0	0
LAKENHEATH	1.0000	0.00	1.72	0.00	24.27	0	3,955,786	0	0	0	0	0	2,938,310	0	0

Distance Calculator Worksheet

Potential Beddown Location	Latitude		Longitude								
ALI AL SALEM AB	29.21000	N	47.31998	E	29.21000	-47.31998	29.35000	47.53330	29.35000	-47.53330
Kuwait International	29.22657	N	47.96893	E	29.22657	-47.96893	29.37761	48.61488	29.37761	-48.61488
Baghdad INTL	33.16002	N	44.13998	E	33.16002	-44.13998	33.26670	44.23330	33.26670	-44.23330
KANDAHAR INTL	31.30000	N	65.51000	E	31.30000	-65.51000	31.50000	65.85000	31.50000	-65.85000
THUMRAIT	17.40002	N	54.01002	E	17.40002	-54.01002	17.66670	54.01670	17.66670	-54.01670
Al Udeid	25.07020	N	51.18540	E	25.07020	-51.18540	25.11700	51.30900	25.11700	-51.30900
RAMSTEIN AB	49.25998	N	7.36000	E	49.25998	-7.36000	49.43330	7.60000	49.43330	-7.60000
ROTA NS	36.39000	N	6.21000	W	36.39000	6.21000	36.65000	6.35000	36.65000	6.35000
ALTUS AFB	34.40002	N	99.16002	W	34.40002	99.16002	34.66670	99.26670	34.66670	99.26670
LAKENHEATH	52.25002	N	0.34002	W	52.25002	0.34002	52.41670	0.56670	52.41670	0.56670

Refuel Points	Latitude		Longitude							
Mosul	36.28380	N	42.86290	E	36.28380	-42.86290	36.47300	43.43817	36.47300	-43.43817
Anbar	32.78860	N	41.99950	E	32.78860	-41.99950	33.31433	42.66583	33.31433	-42.66583
Kuwait	29.78750	N	47.27660	E	29.78750	-47.27660	30.31250	47.46100	30.31250	-47.46100
Turkey	38.38900	N	41.36990	E	38.38900	-41.36990	38.64833	41.61650	38.64833	-41.61650
Saudi Arabia	25.33220	N	44.36810	E	25.33220	-44.36810	25.55367	44.61350	25.55367	-44.61350
Yemen	13.45000	N	43.30460	E	13.45000	-43.30460	13.75000	43.50767	13.75000	-43.50767
Diyala	33.35270	N	45.23790	E	33.35270	-45.23790	33.58783	45.39650	33.58783	-45.39650
An Najaf	31.60300	N	44.65930	E	31.60300	-44.65930	32.00500	45.09883	32.00500	-45.09883
Saudi Arabia 2	30.49700	N	40.06070	E	30.49700	-40.06070	30.82833	40.10117	30.82833	-40.10117
Red Sea	22.35180	N	37.47030	E	22.35180	-37.47030	22.58633	37.78383	22.58633	-37.78383

Distance Calculations

Refuel Points

	Mosul	Anbar	Kuwait	Turkey	Saudi Arabia	Yemen	Diyala	An Najaf	Saudi Arabia 2	Red Sea	AVERAGE
ALI AL SALEM AB	**474**	**345**	**58**	**630**	**276**	**962**	**277**	**203**	**396**	**664**	**428**
Kuwait International	**499**	**386**	**82**	**656**	**313**	**980**	**302**	**240**	**450**	**712**	**462**
Baghdad INTL	**196**	**79**	**242**	**347**	**463**	**1172**	**61**	**87**	**256**	**726**	**363**
KANDAHAR INTL	**1151**	**1177**	**948**	**1260**	**1173**	**1626**	**1040**	**1058**	**1320**	**1587**	**1234**
THUMRAIT	**1260**	**1120**	**839**	**1416**	**706**	**651**	**1062**	**987**	**1095**	**960**	**1010**
Al Udeid	**792**	**668**	**373**	**949**	**364**	**812**	**595**	**527**	**685**	**757**	**652**
RAMSTEIN AB	**1734**	**1827**	**2129**	**1586**	**2234**	**2772**	**1918**	**1971**	**1839**	**2150**	**2016**
ROTA NS	**2371**	**2392**	**2685**	**2256**	**2669**	**2993**	**2515**	**2534**	**2321**	**2427**	**2516**
ALTUS AFB	**6050**	**6193**	**6471**	**5894**	**6644**	**7204**	**6248**	**6323**	**6249**	**6583**	**6386**
LAKENHEATH	**2072**	**2174**	**2474**	**1921**	**2588**	**3127**	**2260**	**2316**	**2193**	**2505**	**2363**

UTE Calculator Worksheet

		Aircraft Cycle	Aircraft UTE Rate (sorties per day)	Tanker Sorties Required	Aircraft Required	Max Sorties per Day	Maximum Aircraft Available
1	ALI AL SALEM AB	9.32	2.58	8.93	7.61	30.64	14.00
2	Kuwait International	6.79	3.53	8.93	6.50	57.08	19.00
3	Baghdad INTL	7.24	3.31	8.93	6.70	30.99	11.00
4	KANDAHAR INTL	11.97	2.01	8.93	8.77	13.63	8.00
5	THUMRAIT	10.09	2.38	8.93	7.95	38.41	19.00
6	Al Udeid	6.13	3.92	12.50	7.29	46.59	14.00
7	RAMSTEIN AB	13.29	1.81	8.93	9.35	13.81	9.00
8	ROTA NS	13.65	1.76	8.93	9.50	19.43	13.00
9	ALTUS AFB	37.38	0.64	8.93	19.89	10.37	19.00
10	LAKENHEATH	18.70	1.28	8.93	11.71	20.73	19.00

Offload Calculator Worksheet

	Potential Beddown	KC-10 Average Offload per Sortie	KC-135R Average Offload per sortie	KC-135E Average Offload per Sortie	Average Offload per Sortie
1	ALI AL SALEM AB	183,047	69,079	26,576	92,901
2	Kuwait International	220,399	107,447	64,750	130,865
3	Baghdad INTL	257,239	112,278	70,158	146,559
4	KANDAHAR INTL	159,215	69,746	22,539	83,834
5	THUMRAIT	205,996	80,703	34,806	107,168
6	Al Udeid	234,322	98,157	54,348	128,942
7	RAMSTEIN AB	97,252	31,566	-20,208	36,203
8	ROTA NS	86,584	7,123	-47,575	15,377
9	ALTUS AFB	-220,055	-181,823	-259,121	-220,333
10	LAKENHEATH	29,741	-25,386	-79,188	-24,944

	Potential Beddown	KC-10 Average 24 hour Offload	KC-135R Average 24 hour Offload	KC-135 Average 24 hour Offload	Average 24 hour Offload
1	ALI AL SALEM AB	1,885,464	711,541	684,369	3,281,374
2	Kuwait International	3,895,124	1,519,134	2,288,643	7,702,902
3	Baghdad INTL	3,410,908	1,488,770	1,627,984	6,527,662
4	KANDAHAR INTL	957,684	559,370	225,958	1,743,012
5	THUMRAIT	2,449,903	767,836	827,900	4,045,639
6	Al Udeid	0	1,537,206	2,127,826	3,665,032
7	RAMSTEIN AB	351,249	228,016	-255,450	323,815
8	ROTA NS	304,471	50,096	-836,475	-481,909
9	ALTUS AFB	-706,438	-466,962	-1,663,698	-2,837,098
10	LAKENHEATH	190,850	-130,324	-1,016,312	-955,786

	Potential Beddown	KC-10 Tanker Generation	KC-135R Tanker Generation	KC-135E Tanker Generation
1	ALI AL SALEM AB	10	10	26
2	Kuwait International	18	14	35
3	Baghdad INTL	13	13	23
4	KANDAHAR INTL	6	8	10
5	THUMRAIT	12	10	24
6	Al Udeid	0	16	39
7	RAMSTEIN AB	4	7	13
8	ROTA NS	4	7	18
9	ALTUS AFB	3	3	6
10	LAKENHEATH	6	5	13

Bibliography

Air Refueling Operations Planning. http://www.air-refueling.com/index

Annaballi, RonJon. A Multiple Ant Colony Metaheuristic for the Air Refueling Tanker Assignment Problem. AFIT Thesis. Air Force Institute of Technology (AU), Wright Patterson AFB, OH March 2002

Air Force Link. KC-10 Extender Fact Sheet. Online Publication. n. pag. 16 August 2005. http://www.af.mil/factsheets/factsheet.asp?fsID=109.

Air Force Link. KC-135 Stratotanker Fact Sheet. Online Publication. n. pag. 16 August 2005. http://www.af.mil/factsheets/factsheet.asp?fsID=110.

Begert, William J. "Kosovo and Theater Air Mobility," Aerospace Power Journal, 13, 4: 11-21 (Winter 1999).

Cohen, David M., The Vital Link, The Tanker's Role in Wining America's Wars, Fairchild Paper, Air University Press, Maxwell Air Force Base, AL March 2001

Department of the Air Force. Air Force Basic Doctrine. AFDD 1. Washington: HQ USAF, 17 November 2003.

Department of the Air Force. Air Mobility Planning Factors. AFPAM 10-1403. Washington: HQ USAF, 18 December 2003.

Department of the Air Force. Air Refueling. AFDD 2-6.2. Washington: HQ USAF, 19 July 1999.

Department of the Air Force. C/KC-135 Operations Procedures. AFI 11-2KC-135 v3. Washington: HQ USAF, 1 December 1999.

Department of the Air Force. General Flight Rules. AFI 11-202 v3. Washington: HQ USAF, 16 February 2005.

Department of the Air Force. AFI 11-2KC-10 v3. Washington: HQ USAF, 1 September 1999.

Government Accounting Office. DOD Needs to Determine its Aerial Refueling Requirements. Report Number GAO 04-349. Washington DC: GAO, 2004.

Government Accounting Office. Operation Desert Storm: An Assessment of Aerial Refueling Operational Efficiency. Report Number GAO/NSIAD-94-68. Washington DC: GAO, 1993.

MacDonald, Mark J. Handbook for Tanker Employment Modeling. Graduate Research Project. School of Engineering and Management, Air Force Institute of Technology (AU), Wright Patterson AFB, OH, June 2005.

Miller, Jeffrey R. A Capacitated Facility Location Approach for the Tanker Employment Problem. AFIT Thesis. AFIT, Wright Patterson AFB OH, March 2005 (AFIT/GOR/ENS/05M-12)

Romero, Margaret M. Algebra of Tankers. AFIT Thesis. School of Engineering and Management, Air Force Institute of Technology (AU), Wright Patterson AFB, OH, March 2006.

Swartz, K. "Great Circle Mapper Utility Tool." http://gc.kls2.com. 15 February 2004.

Sere, Michael C. Strategic Airlift En Route Analysis and Considerations to Support the Global War on Terrorism. AFIT Thesis. Air Force Institute of Technology (AU), Wright Patterson AFB, OH, March 2005.

Wiley, Victor D. The Aerial Fleet Refueling Problem. Ph.D. Dissertation. University of Texas, Austin TX, August 2001

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14. ABSTRACT
With the reduction of forward basing of U.S. military forces, the increase in global operations and a move toward expeditionary forces, the United States Air Force's tanker fleet is increasingly crucial to the success of all military services. Past reductions of the Air Force's tanker fleet and an ever increasing age of the tanker fleet makes fast, efficient, and effective planning a must. A critical aspect of tanker planning, that affects all other aspects of tanker operations, is the beddown decision. Beddown decisions directly affect the amount of fuel that can be offloaded to receivers and the number of tanker sorties that can be flown in support of operations. Given the importance of tanker aircraft to mission success, planners still lack rough cut planning tools that can assist in the early planning stages of tanker employment.

By combining research conducted by Major Mark Macdonald and Captain Michael Sere, a rough cut goal program can be developed that will assist tanker planners in making beddown decision. This tool can provide planners with the data required to make beddown decision based off potential capabilities and possible capability trade-offs. While this tool is not suitable to plan or conduct operations with, it will allow planners to quickly calculate potential capabilities and assist in the planning process.

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